Injury Incidence and Severity at the South African Rugby Union (SA Rugby) Youth Weeks Tournaments: A Four Year Study

By

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Declaration

I, *Jarred Marsh*, hereby declare that the work on which this dissertation/thesis is based is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree in this or any other university.

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This is for you.

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Abstract

Introduction

Rugby Union (hereinafter referred to as 'rugby') is a contact sport with players being exposed to repetitive collisions throughout a match. As the risk of injury is relatively high, incidence surveillance studies within rugby has become popular. However most of the studies have focussed on senior players. The data on injuries among youth rugby players are limited. This makes it difficult to develop the game to make it safer for youth of all ages.

Objectives

The first objective of this study was to establish if any injury trends exist across different ages of youth rugby players (13 to 18 years). The second objective was to determine the patterns of injuries changed over four years (2011 to 2014).

Methods

The South African Rugby Union (SA Rugby) hosts four local youth tournaments annually to for local rugby talent: Craven Week under-13, Grant Khomo under-16, Academy Week under-18 and Craven Week under-18. Injury data were collected from the four SARU Youth Week Tournaments between 2011 and 2014. These data were compiled into one central SARU injury surveillance database. Injury categories were used to group data: *'Type', 'Location', 'Event' and 'Severity'* of injury were assessed. Injuries were defined as either *'Time-loss'* (those injuries that prevented a player from match participation for one or more days), or 'Medical attention' (injuries that required the player to seek medical attention at

the time of or after injury but were not required to miss a match). Injury rates were represented by injury incidence densities (IIDs) (corresponding 95% confidence intervals (95% CIs) for IID were calculated for the number of injuries regardless of whether one person was injured more than once) per 1000 hours of match play. Incidence densities were considered to be significantly different from each other if their 95% CIs did not overlap and using Poisson regression analysis. The injury rate ratio (IRR) was calculated for each tournament by comparing the IIDs from 2011 through to 2014. IRR was considered significantly greater if the lower 95% CI was above 1.0. Conversely, an IRR was considered significantly less if the upper 95% CI was below 1.0.

Results

The *'overall'* combined IID across all four years was 54.6 injuries per 1000 hours of match play (95%CI: 51.0-58.2). The combined *'time-loss'* IID was 18.9 injuries per 1000 hours of match play (95%CI: 16.8-21.0). *'Time-loss'* injuries were greatest in 2011 (23.2 per 1000 match hours (95% CI: 18.5-28.0)). However, *'time-loss'* injuries rates were significantly reduced in 2013, when compared to these injury rates in 2011 (13.3 (9.7-17.0). Craven Week under-13 presented significantly greater 'overall' injury incidence densities when compared to the older age groups (71.9 per 1000 match hours (95% CI: 62.4-81.4)). Overall, joint/ligament/tendon injuries were most common *'overall'* and *'time-loss'* injury sustained by players between 2011 and 2014 (30% and 33% respectively). This was followed closely by concussion injuries, which accounted for 29% of *'time-loss'* and 12% of *'overall'* injuries. A large proportion of both *'overall'* (57%) and *'time-loss'* (55%) injuries occurred during the tackle event, with the tackler being injured more often than the ball-carrier (37% and 18%

respectively). However, there were no statistically significant differences when comparing *'overall'* and *'time-loss'* IID between the different tournaments from 2011 until 2014.

Discussion

Significant differences were found when comparing *'overall'* and *'time-loss'* IID between the different tournaments from 2011 until 2014. Craven Week under-13 presented significantly greater 'overall' injury incidence densities. This finding contradicts previous literature within youth rugby research. The tackle (combination of tackler and ball-carrier) still accounts for the highest proportion both *'time-loss'* and *'overall'* injury events (57% and 55% respectively). This is in accordance with previous studies. However, a point of concern was that concussion accounted for 29% of all 'time-loss' injuries and 12% of all 'overall' injuries. This finding suggests a gradual increase in the number of concussions suffered during the SARU Youth Week Tournaments between 2011 and 2014. Further research is required to determine the reason for this pattern.

Conclusion

Further research within youth rugby cohorts is required to determine the risk associated with involvement at various level of participation. Injury prevention programs should place focus on reducing the prevalence of concussion at youth level by educating players and coaches about safe tackle techniques. Future studies should focus on local youth cohorts for seasonal durations.

Introduction

The benefits of physical activity is well documented (World Health Organisation, Fact Files, Physical Activity). According to the World Health Organisation (hereinafter referred to as 'WHO'), physical activity is defined as '*any bodily movement produced by skeletal muscles that requires energy expenditure'.* Research has shown that a lack of physical activity may lead to the development of non-communicable diseases (WHO, 2017). *Physical inactivity has been identified as the fourth leading risk factor for global mortality causing an estimated 3.2 million deaths globally' (*WHO, 2017). These diseases, such as Cardiovascular Disease, Cancer, Chronic Respiratory Diseases and Diabetes, are largely preventable through involvement in regular physical activity. However, research in 2010 found that 23% of global adults were not active enough (WHO, 2017). Within South Africa, research conducted by WHO in 2008 found that 31% of adults were classified as *'Obese'* (WHO, 2017). These findings show a steady increase in the prevalence of non-communicable diseases due to reduced levels of physical activity. In comparison, the benefits of physical activity at a young age are widely reported and young people world-wide are encouraged to participate in daily activity to promote health and both physical and mental wellbeing (WHO, 2017). The benefits of physical activity in the youth population are similar to that of the adult population (WHO, 2017). Therefore young people are encouraged to participate in daily regular physical activity and sport involvement is encouraged for all ages. Sport participation has numerous positive effects. Van Mechelen et al. (1992) noted there are many reasons for participating in sport with health/fitness and pleasure/relaxation being the most common. Sport has been reported to positively affect the physical development of healthy bones, tissue and the cardiorespiratory system (WHO, 2017). Sport participation has also been

reported to improve adolescent motor control and movement patterns (WHO, 2017). However, despite the positive aspects of participating in sport, there is also a risk of injury. The magnitude of the risk is dependent on the *type* of activity (Van Mechelen et al., 1992). Of all sports, Rugby Union has one of the highest rates of injury (Williams et al., 2015).

The Sport of Rugby

Rugby Union (hereinafter referred to as 'rugby') is an example of structured physical activity that is popular among youth and adults. William Webb Ellis, a pupil attending Rugby House School in the town of Rugby, Warwickshire, England, was credited with starting the game of Rugby Football in 1823 (Guttman, 2004). However it was only in 1845 that the first set of match rules were developed (Corson, 2009). The game of rugby involves two teams of fifteen players. Each team is tasked with progressing down the field of play with the playing ball in possession towards the opposition's goal line (Hendricks and Lambert, 2010). The attacking team is then required to ground the playing ball in the in-goal area (Figure 1.).

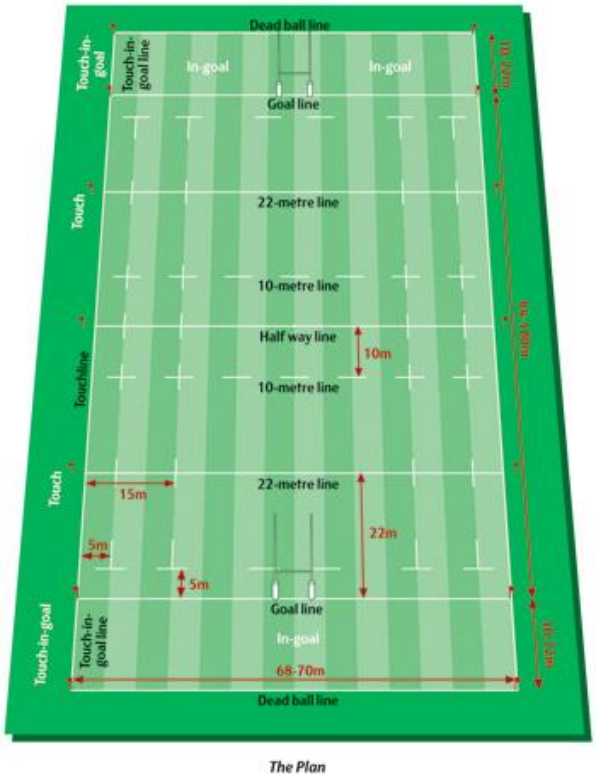

Figure 1. 'The Plan' (World Rugby, 2017c)

The team in possession of the ball aims to score as many points within two periods of forty minutes (80 minutes total for senior rugby) to win the match (Hendricks and Lambert, 2010). The defending team tries to prevent this phase of play from occurring by physically tackling the opponent in possession of the ball and preventing forward progression down the field. While this is happening, the defending team tries to gain possession of the ball. Thus, the rate of contact events is frequent and players are exposed to repetitive "collisions" throughout the 80 minute period. Players are grouped into two positional groups – forwards and backs (Brown et al., 2012). Traditionally, the forwards have a higher body mass and stature than the backs (Lambert and Durandt, 2010) and are involved in set plays such as lineouts and scrums. The forwards are generally involved in more contact collisions than backs (Duthie et al., 2006). However, backs have been shown to experience more severe collisions (>10g) (Venter et al., 2010). These collisions often occur when the players are running at a high velocity, placing them at risk of injury (Brown et al., 2014).

Duthie et al. (2006) found that senior professional players regularly achieve 90-99% of their maximum velocity within a match. It was reported that forwards may achieve this velocity in 42% of total sprints within a match while backs may do so in 53% of total sprints. This study also found that forwards may achieve average velocities of 7.5 $m.s^{-1}$ while backs may achieve average velocities of 8.5 $m.s^{-1}$ (Duthie et al., 2006). It has also been reported that backs accumulate more sprint distance than forwards (Read et al., 2017). Cunningham et al. (2016) compared physical demands of elite under-20 and senior international rugby union players. They assessed physical variables in relation to playing time, such as total distance covered ($m*min^{-1}$), high speed running distance (HSR) ($m*min^{-1}$), and total number of sprints ($sprints*min^{-1}$) (Cunningham et al., 2016). They reported that in general senior players covered more distance ((forwards: 66.8 ± 7.1 vs 61.5 ± 8.0m•min-1) (backs: 73.3 ± 8.1 vs 69.1 ± 7.6m•min-1), when compared to their age grade counterparts, although these findings were not considered significant (Cunningham et al., 2016). Interestingly, under-20 front row forwards (props and hooker) produced higher values for relative HSR (2.5 ± 1.3* vs 1.8 ± 1.1) and total sprints (0.09 ± 0.04* vs 0.06 ± 0.04) than their senior counterparts. This was attributed to the lower body mass of the younger players (119.1 ± 5.0 vs 111.8 ± 5.6 kg) and their potentially greater mobility on the field (Cunningham et al., 2016). In comparison, the senior midfield grouping (inside centre, outside centre) produced significantly greater variables for total relative distance covered (71.9 ± 10.0 vs 70.5 ± 6.8*), HSR (8.0 ± 2.3 vs 7.2 ± 1.7*) and sprints (0.28 ± 0.07 vs 0.27 ± 0.06*). Only the under-20 “back three” (full back and both wings), produced a greater HSR (8.1 ± 1.7* vs 7.4 ± 2.2) and sprints (0.29 ± 0.06* vs 0.27 ± 0.08) value than their senior backs counterparts.

Formats of Rugby

Rugby as we know it today was originally called Rugby Football (Du Toit, 2014). It was only in 1895 that Rugby Football split into two separate formats of the game: Rugby Union and Rugby League (Du Toit, 2014). While the demands of both rugby formats are similar, the structures differ in certain areas of the game (e.g. number of players per team, the breakdown, tackle situation, scrum event, lineouts, etc.) (Gabbett, 2004). There are numerous other formats of Rugby. For example, the Sevens format was created in 1883 in Melrose, Scotland (World Rugby, 2017a). This format, similar to the fifteen-man format, involves two teams of seven players (three forwards, two half-backs and two outside backs) playing for two periods of seven minutes (World Rugby, 2017a). Sevens has grown in popularity since its inception and is now officially played officially as an Olympic sport. Rugby itself has diversified over time and now caters for the female population and includes non-contact versions of the game (Tag Rugby, Six-Down Rugby, etc.).

Participation in Rugby

Rugby is one of the most popular sports in the world. Currently there are over seven million players participating in rugby at various levels (World Rugby, 2017b). Rugby's governing body - World Rugby - has over 102 Member Unions and 18 Associated Unions managing the game of rugby in their respective countries (World Rugby, 2017b). According to World Rugby, in 2015 the total number of registered players increased from 2.56 million to

2.82 million while the total number of non-registered rugby players increased from 4.47 million to 4.91 million (World Rugby, 2017b). In addition to this Williams et al. (2015) reported that the global Rugby participation has grown on an annual basis by 19%. In South Africa, rugby is particularly popular with a verified 219,940 registered players participating locally (Badenhorst et al., 2017). This is comparable to other top ranked nations such as New Zealand (n=148,413) and Australia (n=230,663) (World Rugby, 2017b). It is interesting to note that England has the greatest total number of players (n=340,347). Locally South African rugby is made up of 14 provincial unions (Badenhorst, 2017), which cater for various provincial levels of competition. With these large numbers of participants in South Africa, in combination with the high rate of injury (see 'Introduction'), there is a potentially high rugby-related injury burden in the country.

Youth Rugby in South Africa

Youth rugby tournaments in South Africa have various formats. South African rugby (SA Rugby) promotes four annual merit-based inter-regional competitions: Craven Week under-13, Grant Khomo under-16, Academy Week under-18 and Craven Week under-18 (Burger at al., 2014; Brown et al., 2012). This structure allows for participation at under-13, under-16 and under-18 level (Brown et al., 2012) and is attended by various provincial teams from across the country. The inaugural Craven Week Tournament (formally known as the Danie Craven Week) was established in East London in July 1964 and served to showcase the best schoolboy rugby talent in South Africa (Brown et al., 2012). However, the tournament was only open to Caucasian players. In 1980 the tournament was expanded to include players of all ethnic origins. This motion to include players of all ethnic classifications (white, black or

coloured) was progressed in 1987 when the Project Tournament was introduced and a 50/50 quota system was implemented. Today provincial teams participating in Craven Week under-18 tournament are required to select a minimum of 9 players of ethnic origin (Du Toit, 2014). In addition to this, teams participating in the Academy Week under-18 and Grant Khomo Week under-16 are required to select a minimum of 11 non-white players (Du Toit, 2014). Initially these tournaments catered for 15 teams in 1964, progressing to 28 teams in 1987 and 32 teams in 2000 before finally being formatted to 20 teams in 2001 (including two invitational teams from Namibia and Zimbabwe) (Brown et al., 2012).

Traditionally, the four tournaments have always had different match-related structures in place. Each tournament is completed within one week, however the weekly match day structure varies across the various tournaments (Burger et al., 2014). However, this current structure of the South African Rugby Union Youth Week Tournaments allows for injury incidence data to only be collected over a one week playing period (Burger et al., 2014). The details of each tournament will be discussed in *'Methods: Overview' (page 32).*

Although previous research may have surveyed several teams participating in rugby structures over a longer duration (Haseler et al., 2010; Nicol et al., 2010; Fuller and Molloy, 2011) , the current SA Rugby Youth Week structure requires player to participate in a highly congested contact environment which may increase the risk of injury (Brooks et al., 2005). This, in combination with the varying stages of maturation of participating players, provides a wide spectrum of game-related injury statistics (Nutton et al., 2012).

This high level of competition, coupled with participation in a congested tournament-format and the inherent injury risk of rugby, warrants further investigation into injury rates of these tournaments.

Injury in Rugby

Williams et al. (2015) reported that Rugby's injury burden and incidence is comparable to other full contact sporting codes such as American Football and Australian Football. As with these sports injury burden and incidence surveillance within rugby has become well documented (Bathgate et al., 2002; Brooks et al. 2005; Fuller et al., 2007; Gabbett, 2008; Gabbett, 2009). Van Mechelen et al. (1992) states that injury surveillance is the first step in the process of the *'sequence of prevention'*, a process whereby the effectiveness of an injury prevention strategy is assessed via four progressive steps. This concept will be discussed further under 'Injury Prevention'. However, due to the nature of this study the following subsections will follow this sequence.

Injury Surveillance

Injury surveillance within rugby has various formats. The Orchards Sports Injury Classification has been a prominent tool in the collection of injury data (Brooks et al, 2005; Meister et al., 2013). However, other tools have also been employed such as the International Classification of Disease (Garraway et al., 2000) and the diagnosis defined by

anatomical location and pathology (Bathgate et al., 2002; Targett, 1998). These various methods of assessment and definitions of injury have made it difficult to compare data from different studies. As a consequence, in 2007 World Rugby formed the Rugby Injury Consensus Group (Fuller and Molloy, 2007). This group comprised the Chief Medical Officer of the World Rugby Board and six other members. They established the '*Consensus statement on injury definitions and data collection procedures for study of injuries in rugby union'* to provide guidelines standardise the research methodology on rugby injury surveillance (Fuller and Molloy, 2007). The long-term goal of this project was to improve the quality of research on rugby injuries.

Injury Definition

As with the epidemiology of other sports injury, the definition of rugby injuries varies substantially. Prior to the introduction of *'Consensus Statement of Injury'* by Fuller et al (2007) there was a large variation in the definition of a rugby-related injury. McIntosh et al. (2005) defined a rugby-related injury as *'any injury requiring on-field treatment or resulting in the player being removed from the field during a rugby game'* while Haseler et al. (2010) and Nicol et al. (2010) reported injury as *'injury resulting in inability to take part in future training or match play'.* Brown et al. (2011) defined rugby-related injuries as either *'time-loss'* or *'medical attention'*. 'Time-loss' injuries were those injuries that prevented a player from match participation for one or more days. 'Medical attention' injuries were those injuries that required the player to seek medical attention at the time of or after injury but were not required to miss a match. This allowed researchers to define the injury based on

the number of days missed. This definition therefore also allowed for establishment of Injury Severity categorization, which will be discussed later.

In addition, this '*Consensus Statement of Injury'* had a separate definition for catastrophic injuries: "*A brain or spinal cord injury or permanent (> 12 months) severe functional disability is referred to as a 'non-fatal catastrophic injury'*."

Injury Risk in Youth and Senior Rugby

Injury Incidence

There have been numerous epidemiological studies examining risk factors such as age (Brown et al., 2012; Leung et al., 2016; McFie et al., 2016), level of participation (Brown et al., 2012; Moore et al., 2015; Fuller et al., 2011; Haseler et al., 2010; Nicol et al., 2010) various formats of the game (McFie et al., 2016; Fuller et al., 2007; Gabbett, 2008; Fuller et al., 2017) and playing position (Hendricks and Lambert, 2010; Freitag et al., 2015). These studies highlight the following areas of concern in rugby injury prevention: concussion (McFie et al., 2016), the tackle situation (Burger et al. 2014; Hendricks and Lambert, 2010, Gabbett, 2008; Sobue et al., 2017) and injury within youth populations participating in rugby (Brown et al., 2012; Burger et al., 2014; Haseler et al., 2010; Nicol et al. 2010; Nutton et al., 2012). Previous research suggests there was a greater incidence of injury associated with a higher level of rugby participation. This finding has been reported on numerous occassions by other researchers (Brown et al., 2011; Haseler et al. 2010; Nicol et al., 2010). However, this may be due to factors such as the size and stature of players (Duthie et al., 2006;

Lambert and Durandt, 2010), muscular strength associated with a high physical maturity (Nutton et al., 2012), greater running velocities and distances, etc. (Duthie et al., 2006; Venter et al., 2010). This trend may be due to the establishment of the professional era of rugby. Bathgate et al (2002) reported that there has been a marked increase in the incident of injury within professional rugby cohorts since the establishment of the professional era in 1995 (47 per 1000 vs. 74 per 1000 player hours; amateur era vs. professional era). These findings are supported by Garraway et al.(2000) who found an increase in incidence of injury within Scottish Border Districts cohorts post-1995 (27% vs. 47%). Previous research also investigated the economic burden of injury, both in time-loss and financial terms. The resulting economic and time-loss burden associated with cases of severe injury in youth populations was high (Brown et al., 2012; Burger et al., 2014). However, although there is a large database of existing research on injury incidence within rugby, the focus has predominantly been focused on senior cohorts (Williams et al., 2015; Gabbett, 2008; Fuller et al., 2007; Brooks et al., 2005). In contrast, recently there has been an increased interest in injury surveillance within the youth rugby population (Haseler et al., 2010; Nicol et al., 2010; Brown et al., 2012; Fuller et al., 2011; Freitag et al., 2015; Nutton et al., 2012; Brown et al., 2014; Burger et al., 2014; McFie et al., 2016; Archbold et al., 2017; Hislop et al., 2017). This may be due to an increased incidence of injury within youth cohorts and a need to determine the risk factors associated with youth participation in the sport (Brown et al., 2012; Burger et al., 2014).

Severity of Injury

Severity of injury refers to the number of days missed from training or match play due to the injury sustained, or the economic burden of the injury (Van Mechelen et al., 1992). Williams et al. (2015) reported that in Rugby, Moderate Injuries (8-28 days absent) were the more common severity of injury (28 injuries per 1000 player hours), while Mild Injuries (4-7 days absent) were close behind (23 injuries per 1000 playing hours). As expected, Severe injuries (more than 28 days absent) accounted for the lease number of injuries (15 injuries per 1000 player hours). This is in agreement with Haseler et al (2010) who found Moderate Injuries to be most prevalent (14 injuries per 1000 player hours).

Brown et al. (2015) reported that youth players participating in a week long rugby tournament incurred an average treatment cost of US$ 731. They found that fracture injuries were the most costly type of injury. Interestingly, it was reported that players without medical insurance incurred a lower treatment cost that players who possessed medical insurance (US$220 vs. US$937). This can be interpreted in a couple of ways. Either players received insufficient medical treatment for their injuries or they discontinued their medical treatment due to financial reasons. Another interpretation is that the players with medical insurance were over serviced.

While injury to a player has a financial consequence, it also also has an effect on team performance (Williams et al., 2016). Williams et al. (2016) reported that time-loss injuries within rugby negatively impacted team performance. This may be due to injuries sustained during a match affecting the team's performance, or the residual psychological or physical effect of the injury affecting the players return to competition (Williams et al. 2016).

Injury Aetiology

Injury Event

Collisions between players is a feature of rugby. It is therefore not surprising that there is a risk of injury associated with this aspect of the game. The tackle event accounts for the greatest incidence of injuries (29 injuries per 1000 player hours), followed closely by the event of Tackling (19 injuries per 1000 player hours) and finally the Ruck/Maul (17 injuries per 1000 player hours) (Williams et al., 2013). The Collision event itself (contact outside of the Tackle event) accounted for 11 injuries per 1000 player hours (Williams et al., 2013). This is consistent with previous research (Brown et al., 2012; Burger et al., 2014; Hendricks et al., 2010) which states the tackle event is the leading cause of injury within rugby. It is interesting to note that younger cohorts experienced a higher number of tackle-related 'time-loss' injuries than adult cohorts (Brown et al., 2012; Burger et al., 2014). This may be due to various causes such as player education, tackle technique, player fatigue, etc. (McFie et al., 2016). Brooks et al. (2005a) reported that 72% of all match-related injuries in senior English professional rugby union players were sustained during contact events. The forwards sustained an overall higher incidence of contact injuries than backs, although backs sustained a significantly higher overall incidence of non-contact injuries (Brooks et al, 2005a).

Type of Injury

According to Williams et al. (2013) the most frequent type of match–related time-loss injury incurred in senior professional rugby cohorts is muscle/tendon injuries (40 injuries per 1000 player hours), followed closely by Joint (non-bone)/Ligament injuries (34 injuries per 1000 player hours). This in agreement to previous research focusing on youth cohorts where muscle injuries were the most common injuries amongst under-13 players at the SA Rugby Youth Week Tournament while under-18 players were more susceptible to Joint/Ligament/Tendon injuries (Brown et al.,2011). This may be due to the under-13 players undergoing a period of peak growth. Nutton et al. (2012) stated that the period of growth around a 'growth spurt', a physical stage of maturation, was associated with increased risk of injury. Nutton et al. (2012) further stated that Peak Height Velocity only subsided at the median age of 14 years old in the North American male youth with the 95% CI ranging from 11.5 to 15.5 years (Nutton et al., 2012). As such, local under-13 players may be at risk of increased risk of injury when experiencing this peak growth period.

Nicol et al. (2010), who assessed incidence of injury within Scottish rugby schools over the second half of their season, found that ligament sprains were the most common type of injury. Interestingly, concussion-type injuries were the second most common type of injury, along with muscle strains. In a South African context, McFie et al. (2016) reported that younger cohorts (under-13 and under-16) are more susceptible to concussion injuries than

slighlty older (under-18) cohorts (8.3 per 1000, 9.1 per 1000 vs 5.5 per 1000 player hours). Between 2011 and 2014 an overall concussion incidence of 6.8 concussons per 1000 player hours was reported at the SA Rugby Youth Week Tournaments. The forwards were more susceptible to concussion than backs (7.5 per 1000 vs 6.1 per 1000 player hours) (McFie et al., 2016). As previously stated, this may be due to the higher number of collisions that forwards experience within a match. However McFie et al. (2016) also reported that a large proportion of concussions sustained were related to the tackle event (3.1 concussions per 1000 player hours) and the ruck event (1.5 concussions per 1000 player hours). This is in agreement with research that found that the tackle event was the leading cause of injury within rugby (Burger et al., 2014; Williams et al., 2013).

Injury Location

Haseler et al. (2010) reported a high prevalence of injury within the the Lower Body region than the Upper Body region when assessing match-related injuries in youth English community players. These findings were supported by Williams et al. (2013) when assessing senior professional players. They found the Lower Limb accounted for 47 injuries per 1000 playing hours while the Upper Limb only accounted for 14 injuries per 1000 player hours in senior cohorts. Interestingly the average reported severity of injury of Upper Limb injuries was 32 days while the severity of Lower Limb injuries was only 19 days. However the authors do not attempt to explain this difference (Williams et al., 2013). Finally, the Head region accounted for 13 injuries per 1000 playing hours (Williams et al., 2013).

New/ Previous Injury

The Injury Consensus Statement classifies a 'previous injury' as *"an injury of the same type at the same site as an index injury which occurs after a player's return to full participation from the index injury".* An index injury refers to the original injury sustained by the player. Williams et al. (2013) found that there was a higher incidence of senior professional players suffering a new injury (78 injuries per 1000 playing hours) than players suffering a previous injury (11 injuries per 1000 playing hours). However, the previous injuries were more severe than new injuries. This shows the importance of correct rehabilitation of injuries before full return to play.

Playing Position

As previously stated, forwards experience a greater number of collision events within a rugby match than backs players (Venter et al., 2011). In contrast to this, Williams at al. (2013) found that there was a greater likelihood for backs to sustain an injury within a rugby match (99 injuries per 1000 player hours) than forwards (94 injuries per 1000 player hours). This may be due to the higher velocities that backs achieve prior to the collision event, or due to the greater amount of space involved prior to the collision event. In contast to Williams et al (2013), McFie et al (2016) assessed concussion incidence rates between 2011 and 2014 in provincial-level youth players. McFie et al. reported that forwards were more

likely to sustain concussion injuries than backs. While their research showed that forwards suffered a higher concussion injury incidence (7.5 concussions per 1000 player hours) when compared to backs (6.1 concussions per 1000 player hours), it was also reported that the Hooker-position sustained the highest concussion incidence rate than all other positions (12.3 concussions per 1000 player hours), followed by loose-forward position (9.8 concussions per 1000 pler hours), while the Scrumhalf-position sustained the lowest (1.9 concussions per 1000 player hours). This may be attributed to these positions experiencing more tackle events within a match, as well as their inherent involvement in the ruck and maul events (McFie et al., 2016). Further investigation into injury risk assiociated with playing position should be conducted to detemine the most 'at risk' positional group.

Limitations of Studies

Injury surveillance studies are difficult to do, and many have limitations because of the constraints around the collection of data. For example, Nicol et al. (2010) found that the small number of Scottish schools participating in the injury surveillance study, as well as only collecting data in the second half of the season, were limitations to their study. Haseler et al. (2010) reported that poor quantification of exposure time in youth injury surveillance was a well-reported limitation. Brown et al. (2011) found that because of the short duration of the SA Rugby Youth Week Tournaments players, may have been less likely to report injuries to the tournament doctor on the final day of the tournaments in favour of being assessed by a family physician. The study of Brown et al. (2011) also focussed only on competition and did not get data for training before or after the competition. Brown et al.

(2011) also mentioned that having multiple physicians assess numerous players may have been a limitation. This would mean that the clinical knowledge of the attending physician would ultimately determine the injury definition, injury type and quality of the data. SA Rugby and BokSmart (Safety programme within SA Rugby) tried to circumvent this limitation by having a detailed data collection form (Appendix 1. and Appendix 2.) that standardised the data as much as possible, as well as the follow up process (Appendix 3).

Injury Prevention

Sports injuries prevention programs should be designed as the aforementioned '*sequence of prevention*' model (Van Mechelen et al., 1992). According to the sequence of events in this model, injury prevention models should be developed based on information gathered in injury surveillance and the investigation of aetiological mechanisms. Finally the effectiveness of the prevention program should be assessed by repeating the first two steps: Injury surveillance and investigating aetiological mechanisms (Figure 2.).

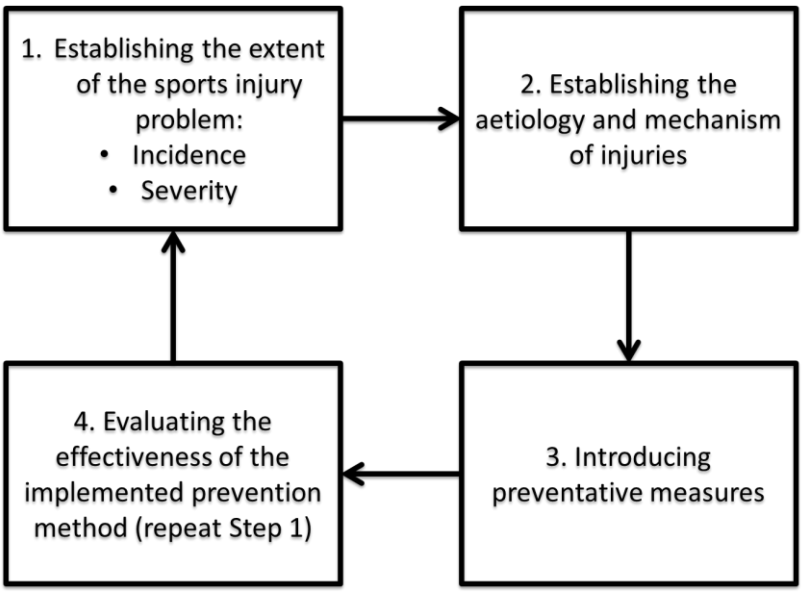

Figure 2. Adapted from the Van Mechelen model (Van Mechelen et al., 1992)

In Rugby, an exemplary program that successfully completed all four stages of the model was the New Zealand Rugby Union's RugbySmart prevention model (Gianotti et al., 2009). RugbySmart was developed in a bid to combat the high number of injuries sustained by rugby players. RugbySmart facilitates compulsory injury prevention courses for all coaches and referees involved in the rugby participation of players at under-13 level and upwards (New Zealand Rugby, Safe Play, 2017). Through this education, RugbySmart has been associated with improvements in player behaviour and incidence rates of targeted injuries (Gianotti et al., 2009) as well as scrum-related neck injuries (Quarrie et al., 2007).

Based on the success of the RugbySmart program in New Zealand, the BokSmart program was formed in July 2009 in South Africa. This arose when SA Rugby and the Chris Burger/Petro Jackson Fund realised that a fundamental issue existed due to the lack of adequate medial infrastructure for players with catastrophic injuries (BokSmart, 2017a). Much like RugbySmart, BokSmart is an education program aimed at coaches and referees. In 2010 BokSmart implemented a compulsory attendance requirement for all coaches and

referees involved in local Rugby. This required all coaches and referees, involved at all levels of local Rugby, to do the course to become accredited (BokSmart, 2017a). As such, today all South African coaches and referees at all levels are required to be BokSmart accredited to participate Rugby (BokSmart, 2017b). As with RugbySmart, the aim of the BokSmart program is to deliver injury prevention education through a coaching-lead process and in turn directly reduce the number of catastrophic injuries experienced locally.

Previous research reports that locally an average of 22 catastrophic rugby-related injuries occur annually within South Africa (Brown, 2011b). In South Africa, Viljoen et al. (2012) reported that the tackle and scrum events contributed to 78% of all serious head, neck and spinal injuries between 2008 and 2011. Brown et al. (2016) found that between 2008 and 2013 seventy-one (n=71) serious rugby-related injuries occurred locally within South Africa. However, it was noted that there was a significant reduction in serious injuries within youth cohorts but not senior cohorts due to the implementation of the BokSmart Program (Brown et al., 2016). The BokSmart program has been associated with improvements in the practice of safe techniques (Brown et al., 2014) such as safe tackling and scrummaging technique. In addition to this BokSmart has recently embarked on establishing the 'Safe Six' injury prevention system. This system utilized six established exercises to target identified anatomical areas of the body in a bid to prevent injury (BokSmart, 2017c).

However, it must be noted that only the RugbySmart programme has completed the Van Mechelen model (*Figure 2.*) by comparing general injury rates before and after the intervention's implementation. Therefore there is a need to compare longitudinal injury rates since the launch of the BokSmart program in South Africa and establish the effectiveness of this program within local youth cohorts (Freitag et al., 2015).

Synopsis

The review of this literature has described the historical growth of the sport of rugby. Locally, this growth has resulted in men and women of all ages and from different ethnic backgrounds playing the games. The number of registered players has increased. As with all contact sports, there is an inherent risk of injury for players.

The literature has shown that globally there is evidence of substantial injury burden and incidence rates amongst the senior rugby population. The main areas of concern are the tackle event, as most injuries occur during this phase of play. Another concern is the high incidence of concussion at all levels of play. In response to these concerns there has been an increased interest in the injury surveillance of youth cohorts in rugby. Studies of youth rugby shows that the likelihood of injury is correlated with the level of participation, and that the tackle event and concussion, much like in senior rugby, are areas of concern. However while the existing research varies in terms of duration of surveillance, few studies have performed surveillance within a youth cohort over consecutive years to assess the changes in injury rates and severity of injury over time. This is particularly important so that injuries can be managed effectively and in response to evidence about the game. This sets the scene for the focus of this thesis.

Research Aims and Objectives

The aim of this study is to assess longitudinal injury rates associated with the four SA Rugby Youth Week Tournaments from 2011 to 2014 (four years). The data collected and assessed

within this study will develop a systematic injury database for future injury incidence investigation.

The aims of this study were to answer the following questions:

1. Are there differences in injury rates between the four age group tournaments?

2. Do the patterns of injury change over the fours years?

Methodology

Overview

Injury data was collected by individual researchers present at each tournament (Appendix 1, 2 – Youth Weeks Injury Data Collection Form 1 and 2). Data pertaining to injury severity, injury location, type of injury and injury event were assessed. Injuries sustained during all SA Rugby Youth Week Tournaments (2011-2014) were transcribed and recorded in the SA Rugby injury-surveillance database (HREC Ref: 438/2011). SA Rugby and the Human Research Ethics Committee of the Faculty of Health Sciences, University of Cape Town granted permission to analyse these data (HREC REF: 944/2014) (Appendix 3). Players participating in each tournament provided consent for their data to be used for research (Appendix 4.). Informed consent was also provided by parents or guardians of these players (Appendix 4.).

Although each tournament lasted one week they were structured differently (See *'Methods', page 42*, Table 1.1 (A-D).), the number of matches played at each tournament was considered when exposure time was calculated. Exposure time was calculated based on the injury collection consensus statement for Rugby (Fuller et al., 2007):

$$\textit{Exposure time} = NM \times PM \times DM$$

(NM is the number of matches, PM is the number of players per match, and DM is the duration of the match in hours).

All the teams in each tournament were included in the study. Therefore PM was calculated as 30 (15 players per team) for each match. It was assumed there were 30 players for the

entire match, thereby ignoring the effects of yellow and red cards on match exposure (Gabbett, 2004). Because of the compact schedule of these tournaments the non-match training hours only had a minor contribution to *'overall'* tournament exposure and non-match injuries were therefore not recorded. An injury collection form was designed based on the Consensus Statement for injury surveillance (Fuller et al., 2007). Demographic information of each injured player, such as the player's team, body height, body weight, age, whether or not the player had medical aid (insurance), and protective gear worn at the time of the injury was also collected. This information was not available for players who were not injured.

The individual structure of each tournament is shown in Table 1.1 (A-D) (See '*Methods'*, *page 42*). Each tournament is structured in a unique way and varies in elements such as number of tournament match days, rest days, duration and exposure hours. Although each tournament incorporates a *'rest day'* into their structure, the positioning of this day varies from tournament to tournament. 'Match Days' or 'Ms', defined as days in which all teams participate in an official tournament match. The Craven Week under-18 tournament varies: only half the teams participate in an alternating fashion over the course of the first four tournament days. Therefore, one 'Match Day' would cover two tournament days to capture all team matches. These days were dubbed 'Tournament Match Days' and represented days on which official match participation occurred. 'Rest Days' were implemented to allow participating teams to recover adequately. Only 'Ms' were used to calculate exposure.

Each team consisted of a squad of 22 players from the 14 provincial rugby unions and invitational teams from countries such as Namibia and Zimbabwe. Each player was required to start and complete one match at the tournament, unless injury or illness prevented him from doing so.

A SA Rugby-appointed tournament doctor (TD) was assigned to each tournament to assess any injury complaint that a player may have had. All players who sustained injuries during a match and required some form of medical treatment were required to report to the TD for evaluation. Qualified medical staff were available at all tournament matches to assist the TD.

Injuries that occurred before the start of the tournament matches were not included in the analyses. The recording of information was performed at all tournaments by one assigned researcher. All the attending researchers underwent data collection training by assessing and reporting on previous cases from previous tournament years. Training was overseen by an experienced researcher who had attended a previous tournament. This was done to ensure continuity through consistent collection techniques. It must also be stated that only reported injuries were recorded. Due to the now semi-professional nature of youth rugby it is commonplace for many teams to employ an independent medical professional to provide medical support to their respective players during training and competition. It is possible that this may have a negative impact on the injury reporting process, although compliance with the tournament rules and regulations is generally high.

Injury definition

As previously mentioned, the injury definition for these tournaments was based on the Rugby Injury Consensus Statement by Fuller et al. (2007): *'Any physical complaint, which was caused by a transfer of energy that exceeded the body's ability to maintain its structural and/or functional integrity, that was sustained by a player during a rugby match and required attention from the SA Rugby Tournament Doctor (TD)'*. Due to the structural design of the tournament, only match-day injury data were collected. With this in mind, the injury definition of Brown et al. (2011) was also adopted to categorize injuries sustained at the tournament. Injuries were defined as either 'Medical attention' injuries resulting in no loss in recreational, play or practice time. A 'time-loss' injury was defined as an injury that resulted in the player being absent for more than one match in a tournament, or more than one day of normal/planned recreational activities after the tournament."

Injury severity

Severity was initially estimated by the TD on consultation. Suspected *'time-loss'* injuries were followed up at the tournament. Players with *'time-loss'* injuries were contacted weekly after the tournament to confirm the severity of injury. Severity was calculated as the days missed from the day of the injury until return to normal sporting activities or at the termination of treatment, depending on which came first. Further grouping of injuries involved categorizing injuries into *'Minor', 'Minor/Moderate', 'Moderate/Severe'* or *'Severe'* depending on the amount of days of training were missed post-injury.

Some studies only report *'time-loss'* injuries (see 'Injury definitions') for uniformity of injury comparisons. However, we also decided to include '*medical attention'* injuries and injuries classified as *'unsure'* in this study. *'Unsure'* injuries denoted an injury that could not be classified by the TD in terms of severity. This decision was based on the importance of using the data in assisting the SA Rugby medical division in making strategic decisions about medical services at tournaments.

Injury type

The *'type'* of injury categories were grouped into one of the following categories: concussion, spinal cord, broken bone/fracture, joint/ligament/tendon, muscle, bruise, laceration (including skin abrasion), or other by the TD. If the TD was unable to diagnose the injury (this only occurred for some '*medical attention'* injuries) the injury *'type'* was recorded as *'unsure'*.

Previous injury

According to the injury consensus statement a *'previous injury'*, or recurrent injury, is *"an injury of the same type at the same site as an index injury which occurs after a player's return to full participation from the index injury".* An index injury refers to the original injury sustained by the player. For the purpose of this study only injuries occurring within the first 12 months after the original index injury were classified as *'previous injury'*. It is important

to note for laceration injuries that any sutured lacerations that re-opened or required re-suturing during the tournament were also classified as *'previous injury'*.

Playing Position Experience

Players who sustained an injury during one of the SA Rugby Youth Week Tournaments were asked questions based on playing position (forwards or backs) and experience (in years) that they had playing in the specific playing position when they sustained their current injury. This playing experience was categorized into less than 1 year, between 1 and 2 years, between 2 and 4 years, between 5 and 10 years, or greater than 10 years of experience in their playing position at the time of injury.

Statistical analyses

Exposure was calculated as described earlier (see '*Methodology, Overview', page 32*). For every tournament match where two teams competed against each other, this was considered one team match. The methods described by Knowles et al. (2006) were used to calculate 95% confidence intervals (95% CI). Injury rates were represented by injury incidence densities (IIDs) (corresponding 95% CIs for IID were calculated for the number of injuries regardless of whether one person was injured more than once) per 1 000 hours of match play (Brooks et al., 2005). Incidence densities were considered to be significantly different from each other if their 95% CIs did not overlap (Freitag et al., 2015).

Poisson regression analysis using IBM SPSS Statistics 24 (2016) was performed to determine if there was a significant change in injuries over time, and between tournaments.

Results

Overview of Tournaments

Injury surveillance was conducted on the 7348 players involved in all matches at the Youth Week Tournaments between 2011 and 2014. Three Hundred and thirty-four teams participated in the various age-specific tournaments with each team comprising of 22 squad members. In total, 16195 hours of exposure time were reported.

Tournament structure remained the same while match duration for the Craven Week under-13 tournament varied in 2014 when compared to the previous three years (see '*Methods', page 42,* Table 1.1(A).). There were a total of 875 injury events across all four years. These injuries occurred in 12% of all players participating (i.e. required medical attention from the TD). 23 players experienced a second injury, regardless of injury severity. Three hundred and sixty (n = 360) injuries were initially diagnosed as *'time-loss'* events and 84% (n = 303) of these were confirmed to be *'time-loss'* injuries either on subsequent tournament days or telephonically after the tournament (Brown, 2012). The remaining 14% were reclassified as either '*medical attention'* injuries or *'unsure'* if it was not possible to follow-up these players. Twenty-four (n=24) injuries that were originally classified as either *'medical attention'* or *'unsure'* injuries were reclassified as *'time-loss'* injuries through the same process. Sixteen (n = 16) injuries remained classified as *'unsure'* injuries while a further 36 injuries were reclassified, totalling fifty-two *'unsure'* injuries (n = 52) (Figure 3.).

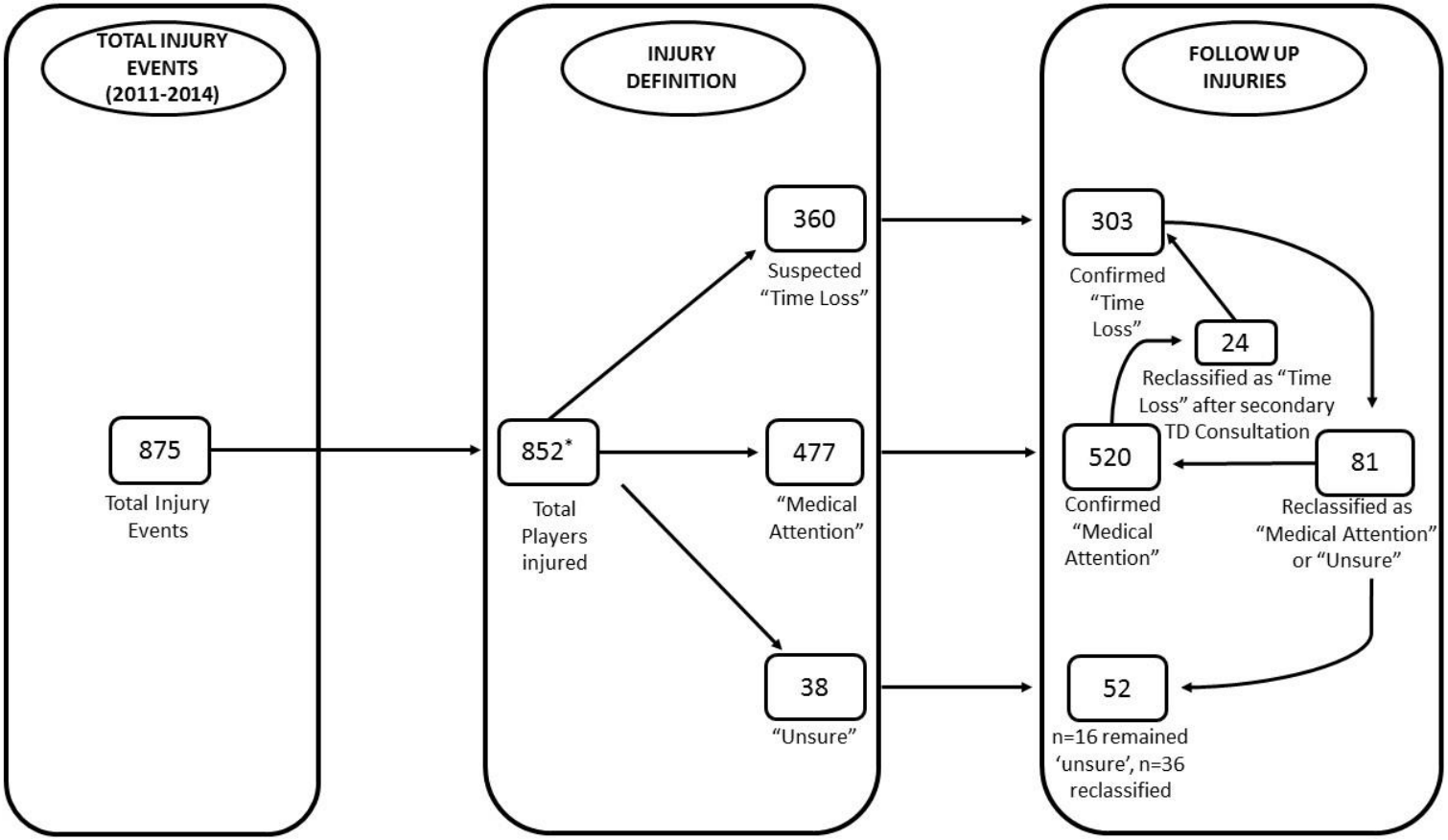

*Figure 3 . Breakdown of Injury Events at all South African Rugby Union (SA Rugby) Youth Week tournaments 2011-2014.**

TD = Tournament Doctor

* 23 Players sustained 2 injuries within the tournament accounting for the difference between total number of injuries and total number of injured players

Injury-incidence density (IID) and Injuries per Match

The *'overall'* combined IID across all four years was 54.6 injuries per 1000 hours of match play (95%CI: 51.0-58.2). The combined *'time-loss'* IID was 18.9 injuries per 1000 hours of match play (95%CI: 16.8-21.0). Grant Khomo under-16 had the lowest *'overall'* IID (30.0 (18.7-41.3)), as well as the lowest '*time-loss'* IID (6.7 (1.3-12.0) in 2013. Conversely, Craven Week under-13 had the highest *'overall'* IID in 2014 (86.7 (67.4-105.9)) as well as the highest '*time-loss'* IID (30.0 (18.7-41.3)). Collectively, the Craven Week under-13 tournament showed a significantly higher *'overall'* IID when compared to the other three tournaments (71.9 (62.4-81.4*)). When comparing injury rates of all four tournaments combined, 2014 had the greatest '*overall'* injury count (n=263), IID (62.4 (54.7-69.9) and the highest absolute number of *'overall'* injuries per match (n=1.9). The greatest '*time-loss'* injury count (n=92), IID (23.2 (18.5-28.0*) and the highest absolute number of *'time-loss'* injuries per match (n=0.7) occurred in 2011 (Table 2.1.). This finding was statistically significant when compared to the '*overall*' and *'time-loss'* IID of 2013 ((45.6 (38.9-52.3) and 13.3 (9.7-17.0), respectively). Academy Week-18 had the highest absolute number of *'overall'* injuries per match (n=1.7) while Craven Week-18 had the highest absolute number of *'time-loss'* injuries per match (n=0.7) when compared to the other tournaments (Table 2A.).

Table 1.1(A). Comparative descriptive statistics of the South African Rugby Union (SA Rugby) Youth Week Tournaments, 2011-2014.

Craven Week under-13				
Year	**2011**	**2012**	**2013**	**2014**
Teams (*n*)	**18**	**18**	**18**	**18**
Matches (*n*)	**36**	**36**	**36**	**36**
Duration (min)	**40**	**40**	**40**	**50**
Structure	**M,M,R,M,M**			
Exposure (hours)	**720**	**720**	**720**	**900**
All Injuries (n)	**31**	**62**	**49**	**78**
TL Injuries (n)	**12**	**20**	**14**	**27**

M = 'match day'; R = 'rest day'; TM = 'tournament match day'

Table 1.1(B). Comparative descriptive statistics of the South African Rugby Union (SA Rugby) Youth Week Tournaments, 2011-2014.

Grant Khomo under-16				
Year	**2011**	**2012**	**2013**	**2014**
Teams (*n*)	**18**	**20**	**20**	**20**
Matches (*n*)	**27**	**30**	**30**	**30**
Duration (min)	**60**	**60**	**60**	**60**
Structure	**M,M,M,M,R,M**			
Exposure (hours)	**810**	**900**	**900**	**900**
All Injuries (n)	**37**	**56**	**27**	**48**
TL Injuries (n)	**16**	**22**	**6**	**22**

M = 'match day'; R = 'rest day'; TM = 'tournament match day'

Table 1.1(C). Comparative descriptive statistics of the South African Rugby Union (SA Rugby) Youth Week Tournaments, 2011-2014.

Academy Week under-18				
Year	**2011**	**2012**	**2013**	**2014**
Teams (*n*)	**26**	**26**	**26**	**26**
Matches (*n*)	**39**	**39**	**34**	**39**
Duration (min)	**70**	**70**	**70**	**70**
Structure	**M,M,R,M**			
Exposure (hours)	**1365**	**1365**	**1190**	**1365**
All Injuries (n)	**69**	**68**	**46**	**77**
TL Injuries (n)	**34**	**18**	**9**	**24**

M = 'match day'; R = 'rest day'; TM = 'tournament match day'

Table 1.1(D). Comparative descriptive statistics of the South African Rugby Union (SA Rugby) Youth Week Tournaments, 2011-2014.

Craven Week under-18				
Year	**2011**	**2012**	**2013**	**2014**
Teams (*n*)	**20**	**20**	**20**	**20**
Matches (*n*)	**30**	**29**	**30**	**30**
Duration (min)	**70**	**70**	**70**	**70**
Structure	**TM,TM,TM,TM,R,TM**			
Exposure (hours)	**1050**	**1015**	**1050**	**1050**
All Injuries (n)	**52**	**61**	**54**	**60**
TL Injuries (n)	**30**	**19**	**23**	**7**

M = 'match day'; R = 'rest day'; TM = 'tournament match day'

Table 2.1. Comparative descriptive statistics of the South African Rugby Union (SA Rugby) Youth Week Tournaments, 2011-2014.

SA RUGBY YOUTH WEEK TOURNAMENTS					
Year	**2011**	**2012**	**2013**	**2014**	**OVERALL**
Teams (*n*)	82	84	84	84	334
Matches (*n*)	132	134	130	135	531
Exposure (hours)	3945	4000	3860	4215	16020
All Injuries (n)	**189**	**247**	**176**	**263**	**875**
IID (95% CI)	47.9 (41.1-54.8)	61.8 (54.0-69.5)	45.6 (38.9-52.3)	62.4 (54.7-69.9)	54.4 (50.8-58.0)
TL Injuries (n)	**92**	**79**	**52**	**80**	**303**
IID (95% CI)	23.2 (18.5-28.0)*	19.8 (15.4-24.1)	13.3 (9.7-17.0)*	18.8 (16.7-20.9)	18.9 (16.8-21.0)

**Denotes significant difference between TL IID 2011 vs 2013*

Table 2.2. Comparative descriptive statistics of the combined injury rates during South African Rugby Union (SA Rugby) Youth Week Tournaments, 2011-2014.

SA RUGBY YOUTH WEEK TOURNAMENTS					
Year	**CW13**	**GK16**	**AW18**	**CW18**	**OVERALL**
Teams (*n*)	72	78	104	80	334
Matches (*n*)	144	117	151	119	531
Exposure (hours)	3060	3510	5285	4165	16020
All Injuries (n)	**220**	**168**	**260**	**227**	**875**
IID (95% CI)	71.9 (62.4-81.4)*	47.9 (40.6-55.1)	49.2 (43.2-55.2)	54.5 (47.4-61.6)	54.4 (50.8-58.0)
TL Injuries (n)	**73**	**66**	**85**	**79**	**303**
IID (95% CI)	23.9 (18.4-29.3)	18.8 (14.3-23.3)	16.1 (12.7-19.5)	19.0 (14.8-23.1)	18.9 (16.8-21.0)

**Denotes significantly higher IID for CW13 vs when compared to older age groups*

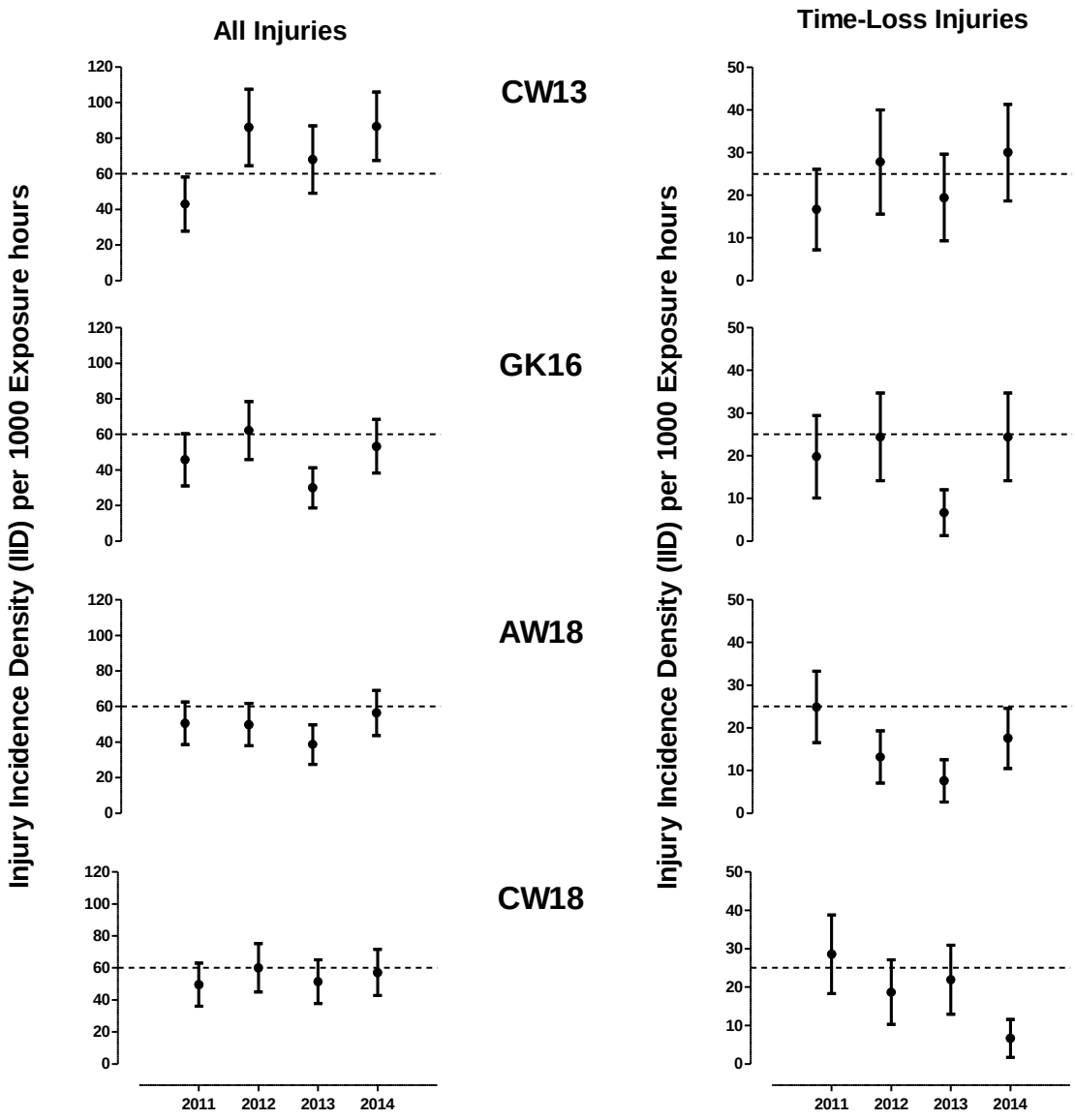

Fig. 4.1. Comparative Time-loss Injury Incidence Density scores of the South African Rugby Union (SA Rugby) Youth Week Tournaments, 2011-2014.

Injuries events, injury type and location

Overall, joint/ligament/tendon injuries were most common *'overall'* and *'time-loss'* injury sustained by players between 2011 and 2014 (Table 2A., 2B.). Joint/ligament/tendon injuries accounted for 38% of *'time-loss'* and 30% of *'overall'* injuries. This was followed closely by concussion injuries which accounted for 29% of *'time-loss'* and 12% of *'overall'* injuries. Academy Week under-18 had the highest Joint/ligament/tendon *'time-loss'* injury proportion (45%) while Grant Khomo under-16 sustained the highest concussion *'time-loss'* injury count (33%).

A large proportion of both *'overall'* (57%) and *'time-loss'* (55%) injuries occurred during the tackle event (Table 3A., 3B.). Overall, the tackler was injured more often than the ball-carrier (37% and 18% respectively) (Table 3A., 3B.). The Craven Week under-13 tournament had the largest proportion of *'time-loss'* tackle-related injuries (65%) as well as the largest proportion of *'overall'* tackle-related injuries (59%). Apart from the tackle situation (tackling and ball-carrying), the ruck was the second highest contributor to *'overall'* and *'time-loss'* injury across all of the age groups (18% and 20% respectively).

In terms of severity, the proportion of Serious Injuries, or *severe/moderate* (player missing out on eight or more days of planned activity) varied by tournament. Overall, severe/moderate injuries accounted for 21% of all injuries (n=187). Craven Week under-18 had the largest proportion of severe/moderate injuries (7%, n=63).

Table 2A. Proportion of injury *'type'* per tournament at South African Rugby Union (SA Rugby) Youth Week Tournaments, 2011-2014.

***'Time-loss'* (TL) injuries are reported separately and as part of the 'Overall' injuries category. The proportion of the different *'types'* of injuries, as diagnosed by the Tournament Doctor, are shown below. The total injuries and calculated number of injuries per match are found below this.**

	CW13		GK16		AW18		CW18		OVERALL	
Type of injury (%)	**TL**	**ALL**	**TL**	**ALL**	**TL**	**ALL**	**TL**	**ALL**	**TL**	**ALL**
Concussion	23	11	33	19	31	11	29	11	**29**	**12**
Contusion	14	30	9	14	2	15	5	22	**7**	**20**
Fracture	23	9	5	2	11	3	8	4	**12**	**5**
Joint/ligament/tendon	22	20	40	40	45	39	43	29	**38**	**30**
Laceration	1	2	3	14	1	11	6	13	**3**	**10**
Muscle	11	17	7	11	7	15	5	14	**7**	**15**
Skin Abrasion	0	1	2	2	0	0	0	2	**0**	**1**
Spinal Cord	1	0	0	1	0	0	0	0	**0***	**0***
Other	4	8	2	4	1	2	1	4	**2**	**4**
Unsure/Do not know	0	1	2	4	2	4	3	2	**2**	**3**
Total injuries	**73**	**220**	**66**	**168**	**85**	**260**	**79**	**227**	**303**	**875**
Injuries per match (n)	**0.5**	**1.5**	**0.6**	**1.4**	**0.5**	**1.7**	**0.7**	**0.9**	**0.6**	**1.6**

CW13 – Craven Week under-13, GK16 – Grant Khomo under-16, AW18 – Academy Week under-18, CW18 – Craven Week under-18

**These were not followed up and thus this original diagnosis could not be confirmed*

Table 2B. Proportion of injury *'type'* per year at South African Rugby Union (SA Rugby) Youth Week Tournaments, 2011-2014.

***'Time-loss'* (TL) injuries are reported separately and as part of the 'Overall' injuries category. The proportion of the different *'types'* of injuries, as diagnosed by the Tournament Doctor, are shown below. The total injuries and calculated number of injuries per match are found below this.**

	2011		2012		2013		2014		OVERALL	
Type of injury (%)	**TL**	**ALL**	**TL**	**ALL**	**TL**	**ALL**	**TL**	**ALL**	**TL**	**ALL**
Concussion	27	14	24	9	27	15	38	13	**29**	**12**
Contusion	8	16	11	23	6	29	4	15	**7**	**20**
Fracture	9	4	11	4	12	5	15	6	**12**	**5**
Joint/ligament/tendon	37	31	36	30	48	25	34	33	**38**	**30**
Laceration	8	13	3	7	0	13	0	8	**3**	**10**
Muscle	7	14	11	16	6	10	5	17	**7**	**15**
Skin Abrasion	0	1	0	2	0	1	1	0	**0**	**1**
Other	2	3	1	4	0	1	4	7	**2**	**4**
Unsure/Do not know	3	6	3	4	0	1	0	1	**2**	**3**
Total injuries	**92**	**189**	**79**	**247**	**52**	**176**	**80**	**263**	**303**	**875**
Injuries per match (n)	**0.7**	**1.4**	**0.6**	**1.8**	**0.4**	**1.3**	**0.6**	**1.9**	**0.6**	**1.8**

Table 3A. Proportion of injury 'event' per tournament at South African Rugby Union (SA Rugby) Youth Week Tournaments, 2011-2014.

***'Time-loss'* (TL) injuries are reported separately and as part of the 'Overall' injuries category. The proportion of different injury events, as reported by the injured player, are shown below. The total number of tournament injuries and calculated number of injuries per match are shown in the sub-section below the main table. The tackle event has been sub-divided into injury occurring to either tackler or ball-carrier. Open play events do not include running- and kicking-related injuries.**

	CW13		GK16		AW18		CW18		OVERALL	
Injury event (%)	**TL**	**ALL**	**TL**	**ALL**	**TL**	**ALL**	**TL**	**ALL**	**TL**	**ALL**
Tackle	65	59	54	53	64	58	43	51	**57**	**55**
Tackler	36	34	36	38	42	36	33	42	**37**	**37**
Ball-carrier	29	25	18	15	22	22	10	9	**20**	**18**
Maul	0	2	2	2	0	2	3	1	**1**	**2**
Ruck	12	20	20	21	18	21	23	19	**18**	**20**
Scrum	5	4	2	4	1	2	4	4	**3**	**3**
Line-out	3	2	3	1	0	1	0	0	**1**	**1**
Open play	5	4	9	11	8	6	15	11	**10**	**8**
Running/kicking	2	4	8	6	5	7	6	5	**5**	**6**
Unsure/NA	7	5	3	3	4	3	8	9	**5**	**5**
Total injuries	**73**	**220**	**66**	**168**	**85**	**260**	**79**	**227**	**303**	**875**
Injuries per match (n)	**0.5**	**1.5**	**0.6**	**1.4**	**0.5**	**1.7**	**0.7**	**0.9**	**0.6**	**1.6**

CW13 – Craven Week under-13, GK16 – Grant Khomo under-16, AW18 – Academy Week under-18, CW18 – Craven Week under-18

Table 3B. Proportion of injury *'event'* per year at South African Rugby Union (SA Rugby) Youth Week Tournaments, 2011-2014.

***'Time-loss'* (TL) injuries are reported separately and as part of the 'Overall' injuries category. The proportion of different injury events, as reported by the injured player, are shown below. The total number of tournament injuries and calculated number of injuries per match are shown in the sub-section below the main table. The tackle event has been sub-divided into injury occurring to either tackler or ball-carrier. Open play events do not include running- and kicking-related injuries.**

	2011		2012		2013		2014		OVERALL	
Injury event (%)	**TL**	**ALL**	**TL**	**ALL**	**TL**	**ALL**	**TL**	**ALL**	**TL**	**ALL**
Tackle	57	59	65	60	55	50	49	52	**57**	**55**
Tackler	29	34	38	38	42	35	41	41	**37**	**37**
Ball-carrier	28	25	27	22	13	15	8	11	**20**	**18**
Maul	1	1	0	1	2	1	1	4	**1**	**2**
Ruck	21	23	16	19	8	24	24	18	**18**	**20**
Scrum	4	4	1	2	4	5	3	3	**3**	**3**
Line-out	0	1	3	1	2	1	1	1	**1**	**1**
Open play	9	6	6	6	21	11	6	7	**10**	**8**
Running/kicking	2	3	4	5	2	3	12	10	**5**	**6**
Unsure/NA	5	5	5	6	6	4	5	5	**5**	**5**
Total injuries	**92**	**189**	**79**	**247**	**52**	**176**	**80**	**263**	**303**	**875**
Injuries per match (n)	**0.7**	**1.4**	**0.6**	**1.8**	**0.4**	**1.3**	**0.6**	**1.9**	**0.6**	**1.8**

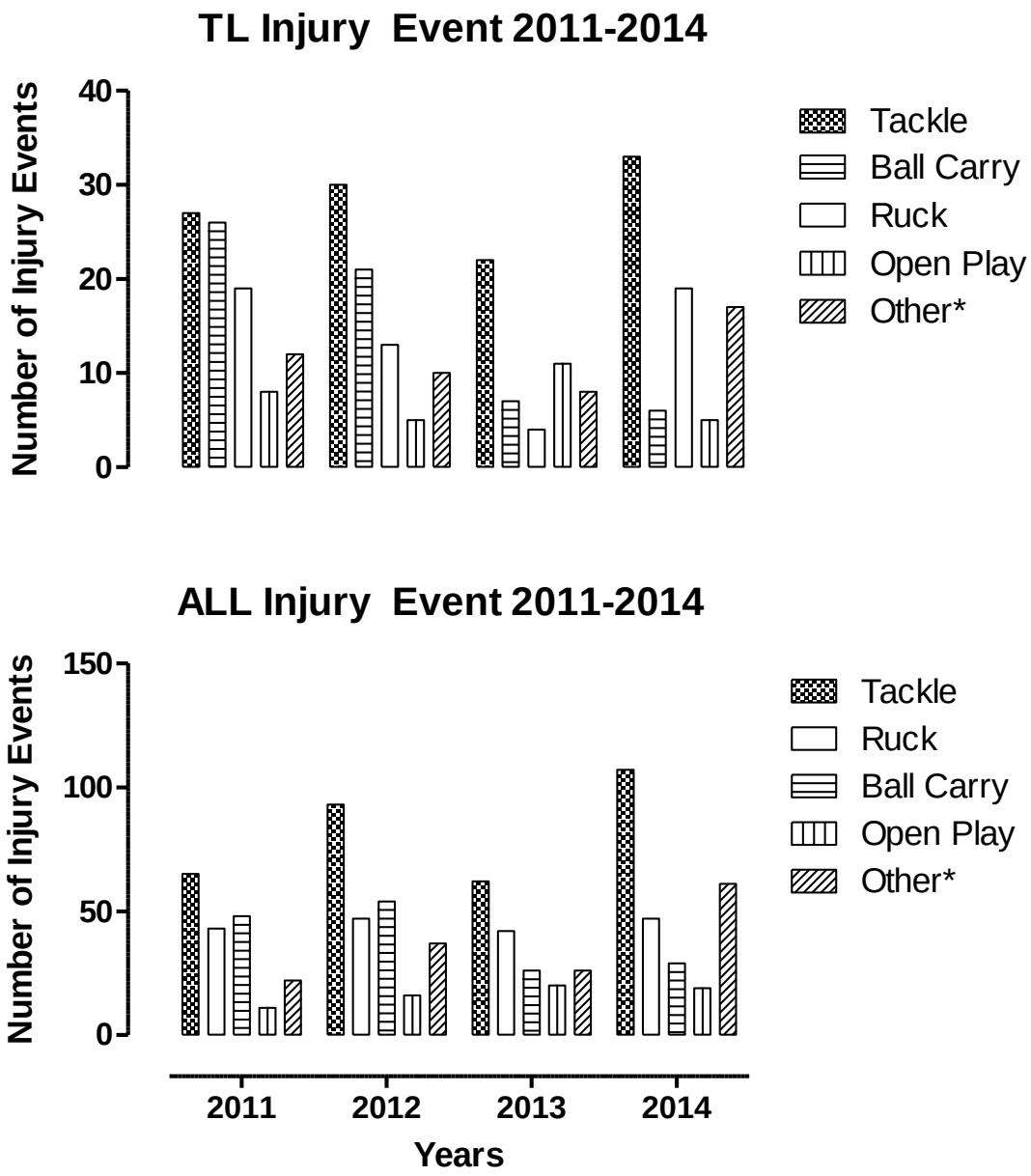

Fig. 5 (A). A comparison of injury 'events' sustained at South African Rugby Union (SA Rugby) Youth Week Tournaments, 2011-2014.

**Any event that accounted for less than 10% of the total count was grouped as "Other": Kicking, Line-out, Maul, Running, Scrum and Unsure. Total number of injuries were as follows: 2011 (189), 2012 (247), 2013 (176), 2014 (263).*

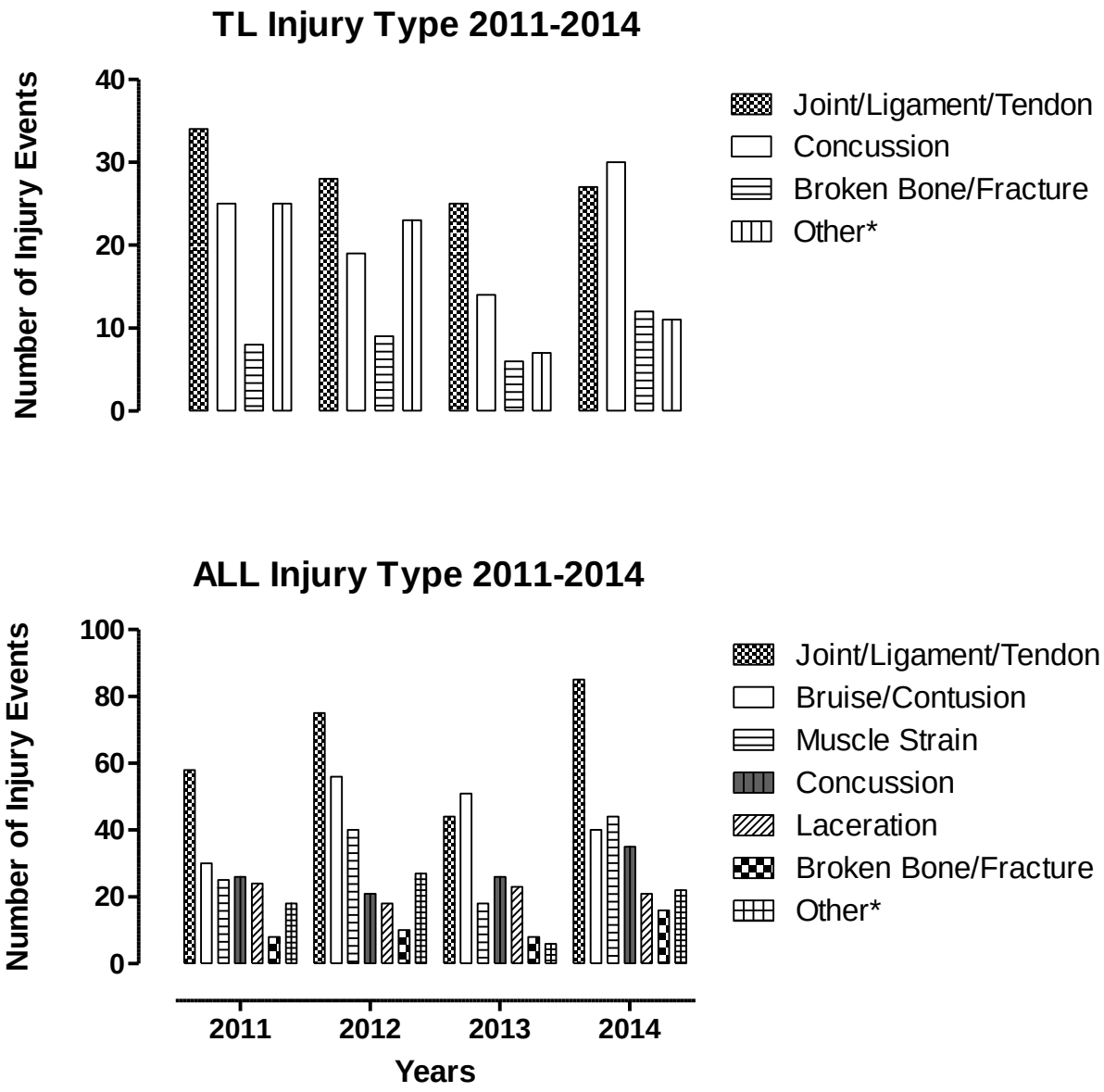

Fig. 5 (B). A comparison of injury 'type' sustained at South African Rugby Union (SA Rugby) Youth Week Tournaments, 2011-2014.

**Any injury type that accounted for less than 10% of the total count was grouped as "Other": Other Injury, Skin Abrasion, Spinal Cord Injury and Unsure. Note: Spinal Cord injury could not be confirmed post-tournament. Total number of injuries were as follows: 2011 (189), 2012 (247), 2013 (176), 2014 (263). "Unsure" injuries (n=8) were excluded from the Figures.*

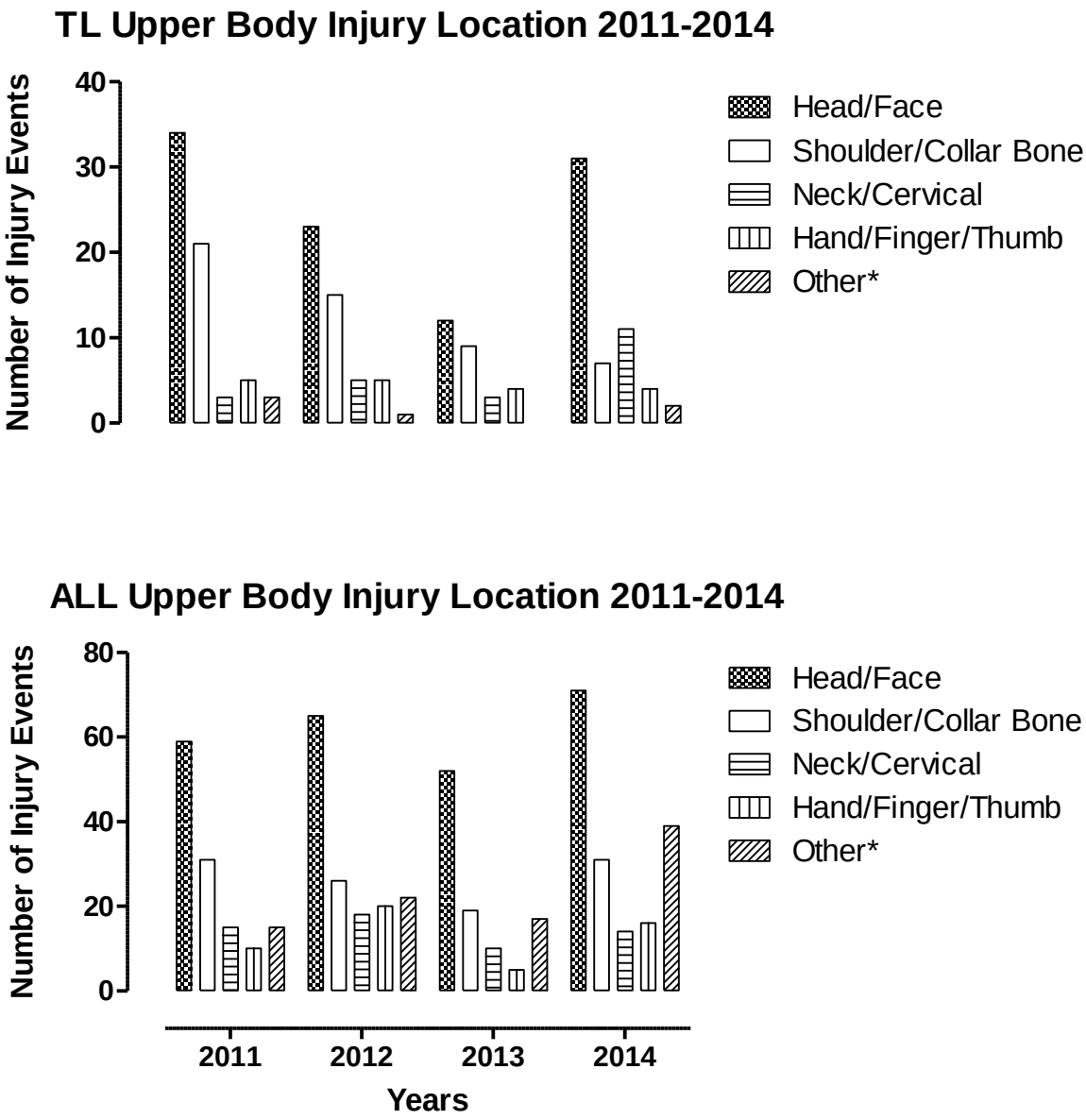

Fig. 5 (C). A comparison of injury 'location' sustained at South African Rugby Union (SA Rugby) Youth Week Tournaments, 2011-2014.

**Any variable that accounted for less than 5% of the total count was grouped as "Other": Elbow, Forearm, Sternum/Ribs, Stomach, Upper Arm, Upper Back and Wrist. Total number of injuries were as follows: 2011 (130), 2012 (151), 2013 (103), 2014 (171)."Unsure" injuries (n=8) were excluded from the Figures.*

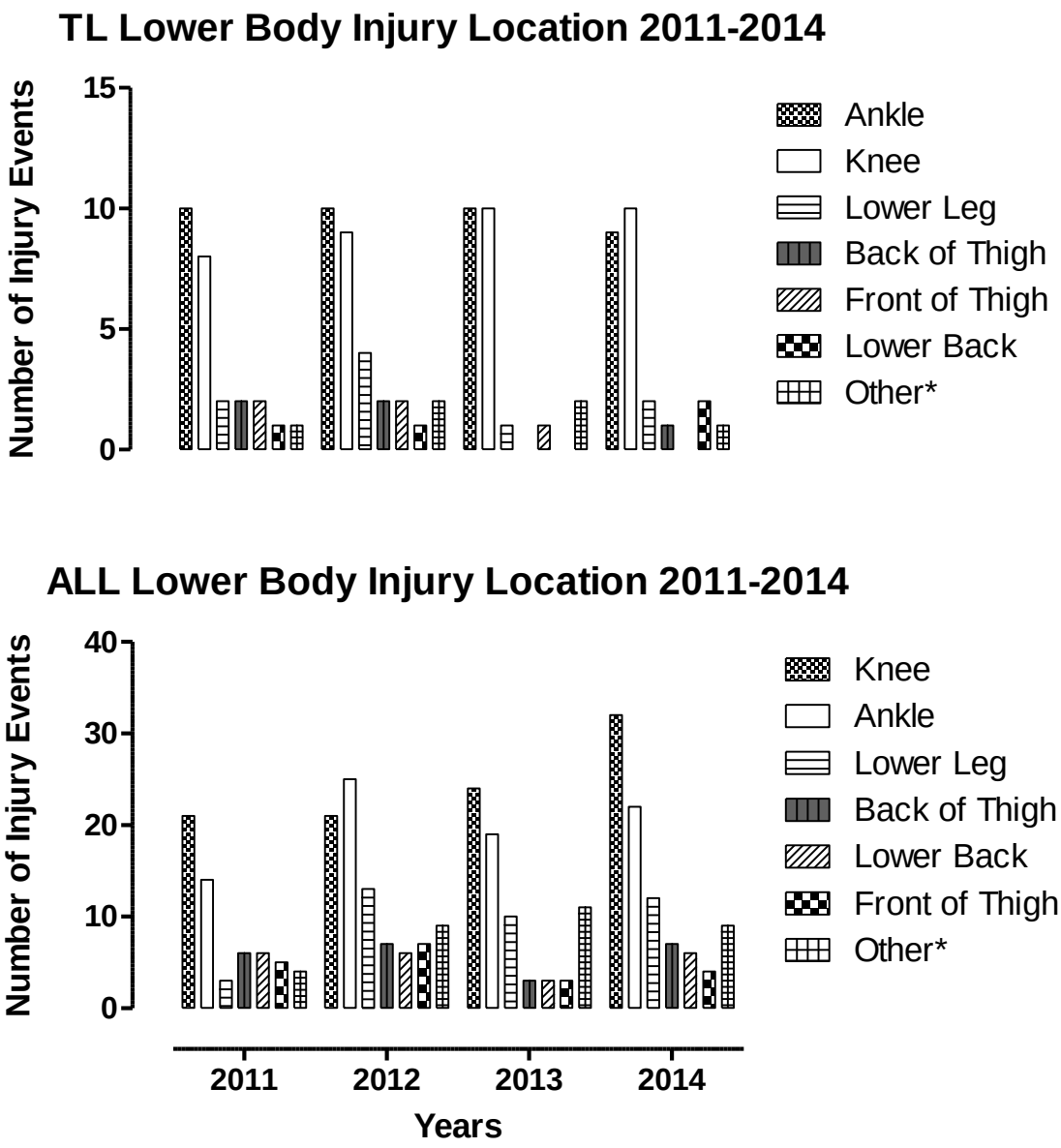

Fig. 5 (D). A comparison of injury 'location' sustained at South African Rugby Union (SA Rugby) Youth Week Tournaments, 2011-2014.

**Any variable that accounted for less than 5% of the total count was grouped as "Other": Foot/Toe, Hip/Groin and Sacrum/Pelvis. Total number of injuries were as follows: 2011 (59), 2012 (88), 2013 (73), 2014 (92). "Unsure" injuries (n=8) were excluded from the Figures.*

Previous Injury

As previously mentioned, a *'previous injury'*, or recurrent injury, is *"an injury of the same type at the same site as an index injury which occurs after a player's return to full participation from the index injury"* and occurred within 12 months of the original index injury. A large percentage of players who sustained an injury across all tournaments between 2011 and 2014 sustained a *'previous injury'* (20% of all injuries incurred). Craven Week under-18 had the highest proportion of all *'previous injury'* cases (39%, n= 66), while 2014 had the highest number of '*previous injury*' cases (37%, n = 64). However, these data are completely subjective and therefore should be viewed as such.

Medical Insurance and Protective Equipment Use

Sixty-seven percent (67%, n= 584) of players injured between 2011 and 2014 reported having medical insurance. Moreover, 68% (n=206) of the 303 players that experienced *'time-loss'* injuries had medical insurance. Of the 875 players injured between 2011 and 2014, 50% (n=437) were wearing a mouth guard at the time of their injury (n=11 unsure) while only 48% (n=145) of players who had suffered a *'time-loss'* injury (unsure=3) were wearing a mouth guard at the time of their injury. Moreover, only 51% (n=125) of players 247 players who suffered Head/Face injuries were wearing a mouth guard at the time of their injury.

Concussion

Concussion injuries accounted for the second highest proportion of *'time-loss'* injuries between 2011 and 2014 (29%, n=88). However, a further 20 concussion injuries were reported as either *'medical attention'* or *'unsure'*. The highest proportion of these concussion injuries occurred in 2014 (32%, n=35). Grant Khomo under-16 had the highest number of concussion injuries between 2011 and 2014 (30%, n=32). Of the 108 reported concussion injuries 9% of these players (n=10) were originally classified as *'time-loss'* at the time of assessment but on follow up were reclassified as *'medical attention'*. This would imply that these players were allowed to continue by team management. Additionally, only 44% (n=47) of all players who sustained a concussion were wearing a mouth guard at the time of the injury. Alarmingly, one player reported sustaining a previous concussion only one month prior to his reported concussion. The majority of players (44%, n=47) who sustained a concussion did so while actively tackling an opponent.

Discussion

Primary Findings

The first finding of this study was that there were indeed significant differences in IIDs when comparing yearly clusters, between 2011 and 2014. *'Time-loss'* injuries were greatest in 2011 (23.2 per 1000 match hours (95% CI: 18.5-28.0)). However, *'time-loss'* injuries rates were significantly reduced in 2013, when compared to these injury rates in 2011 (13.3 (9.7-17.0). It must be noted that no further decrease was noted following this year. *'Overall'* injuries were higher during 2014 (62.4 per 1000 match hours (95% CI: 54.9-69.9)), although this was not a significant finding. The second finding within this study showed there was indeed significant change in injury rates when comparing age groups. Interestingly, Craven Week under-13 presented significantly greater 'overall' injury incidence densities when compared to the older age groups (71.9 per 1000 match hours (95% CI: 62.4-81.4)). This finding is contradicted by previous research conducted by Haseler et al. (2010) and Nicol et al. (2010) who found older age groups had higher injury rates than younger age groups. An explanation for these different findings is that the previous studies took place over a full season and looked at training exposure, while this study measured injuries over a 1 week tournament and focused on competition exposure. Therefore establishing injury surveillance over an extended duration (i.e. a full season, training and competition exposure analysis) may be required to ascertain if a relationship between exposure time in a competitive period and injury rates in this local youth cohort exists.

The high incidence of injury in the under-13 age group may also suggest an underlying issue in players' tackle technique or a disparity in the stature of players involved in the tournament. McFie et al. (2016) reported that both the under-13 and under-16 age groups presented higher concussion incidences than both under-18 tournaments. Due to the event of tackling contributing to 49% of concussion injuries an explanation is that younger players possess less physical, motor, and cognitive development and technical contact skill proficiency than their senior counterparts (McFie et al., 2016). In addition to this fact, the potential for physical mismatch within the under-13 and under-16 age group may be a contributing factor.

Nutton et al. (2012) assessed the potential physical mismatch in youth players aged 12-18 years old in Scottish schools. They found there was a large morphological variation in players within the same age groups, including height, weight and grip strength. They also found that existing parameters defining physical maturation were not suitable for the current rugby-playing school boy population (Nutton et al., 2012) and reported that new criteria should be utilized to determine if youth players have the physical characteristics to participate in a certain age group.

Tournament Structure

As previously mentioned in '*Methods*', (and described in Table 1.1 (A-D).), each tournament is structured in a unique way and varies in elements such as number of tournament match days, rest days, duration and exposure hours. Although each tournament incorporates a *'rest day'* into their structure the positioning of this day varies from tournament to tournament. This may have important implications as to how each team recovers between tournament match days and prepare for their upcoming fixtures. For example, the structure of the Craven Week under-18 tournament required half of the teams to participate per day, in an alternating fashion, for the initial four days. This was followed by a *'rest day'*, after which all teams participated on the final day. In comparison, the remaining three tournaments (Craven Week under-13, Grant Khomo under-16 and Academy Week under-18) required all teams to participate every day, followed by a *'rest day'* before the final tournament day (Brown et al., 2012). Therefore the Craven Week under-13 tournament's structure consisted of the greatest number of matches (n=4) while the remaining tournaments only had three (n=3). This resulted in Craven Week under-13 having the greatest number of overall matches even when compared to older age groups with more participating teams. However, Craven Week under-18 had the greatest competitive exposure time, owing to its longer match durations (see '*Methods*', Table 1.1(D).). As such, the structure of the individual tournaments, and their inherent competitive exposure times, may have a direct impact on the respective incidence of injury experienced at each tournament.

Injury Events

Other findings from this study, consistent with previous literature (Fuller et al., 2007; Haseler et al., 2010) show that a higher *'overall'* proportion of injuries occurred during the tackle situation. The tackle event (a combination of the "tackler" and "ball-carry" events) accounted for more *'overall'* injuries and *'time-loss'* injuries between 2011 and 2014, while the event of tackling itself accounted for more *'overall'* injuries across all tournaments than the ball-carry. This supports previous studies that present similar findings (Burger et al., 2014). Burger et al. (2014) reported that tackle-related injuries accounted for 61% of all *'time-loss'* injuries sustained as SA Rugby Youth Week Tournaments between 2010 and 2011. Of this 61%, the tackler accounted for 55% of tackle-related *'time-loss'* injuries while the ball-carrier accounted for the remaining 45% (Burger et al., 2014). Interestingly, Craven Week under-13 had the highest *'overall'* (53.3 (44.1-62.4)) and *'time-loss'* (19.4 (13.9-24.9)) tackle-related injury rate when compared to AW18 (28.8 (24.2-33.3); 10.4 (7.7-13.2)) and CW18 (27.6 (22.6-32.7); 8.2 (5.4-10.9)). This may have been linked to numerous factors such as variations in physical maturation and body size and poor technique, although neither of these variables were measured in this study. Older, more experienced players have been found to execute a greater proportion of effective tackles, and also miss fewer tackles (Gabbett and Domrow, 2005; Haseler et al., 2010). It has also been found that players may only learn proper tackle technique at an older age (Gabbett, 2001).

It is also interesting to note that Craven Week under-13 tournament is played barefoot. Further research is required to determine if there is a link between footwear and risk of injury within this cohort. The ruck situation was a close second (20%) event associated with

injury, also in agreement with previous research (Lee and Garraway, 1996). Hendricks et al. (2010) noted that in a rugby union match, forwards performed up to 17 tackles per player while backline players performed up to 7 per player. Hendricks et al. (2010) also noted that there had been an increase in average ruck events per match from 25 to 150 between 1972 and 2004 and a decrease in maul events from 50 to less than 25 between 1972 and 2004. Therefore, due to the more frequent occurrence of tackle and ruck events, in comparison to scrums, mauls and lineouts during the match, a higher tackle-related and ruck-related injury occurrence is expected.

Injury Type

As previously mentioned, across both *'overall'* and *'time-loss' injuries*, joint/ligament/tendon injuries were the most prominent type of injury across all tournaments and years. These findings are comparable with previous studies by Fuller and Molloy (2012) and Gabbett (2007). Fuller and Molloy (2012) found that joint (non-bone)/ligament injuries were the most common type of injury when assessing elite under-20 national level players, while Gabbett (2007) reported that joint sprains were the most common type of injury sustained by junior rugby league players over the course of four seasons. Within our study, concussion accounted for the 2nd highest *'time-loss'* and *'overall'* injury proportion. These findings support previous literature from these tournaments (Brown et al., 2012). The highest number of *'overall'* concussion injuries occurred in 2014 (n=35). There has been a gradual increase in the number of *'overall'* concussion injuries between 2011 and 2014. Thirty-five (n=35) *'overall'* concussions were recorded in 2014, up

from 26 *'overall'* concussions in 2011 and 2013. However, it must be noted that this increase in reporting/incidence may be due to the increased awareness of concussion and the long term effects associated with concussion. With this in mind, it is concerning to note that although concussion is reported as *'time-loss'* due to the nature of the injury there is a discrepancy in the number of '*overall'* and *'time-loss'* concussions reported at the tournaments. A total of 108 *'overall'* concussions were reported, however only 88 are reported as *'time-loss'*. This equated to twenty (n=20) concussions being misdiagnosed between 2011 and 2014. This may be due to misdiagnosis of the injured player or poor execution of the recovery guidelines issued to the player and parent/guardian. According to World Rugby statement (World Rugby, 2017d) the player should be monitored for a minimum period of 24 hours post-concussion. Furthermore it states that players diagnosed with a concussion may not return to play or training on the same day. The Sport Concussion Assessment Tool (SCAT3) is utilized in multiple sporting codes throughout the world (Yengo-Kahn et al., 2016). This assessment tool allows trained medical personnel to systematically assess individuals suspected of suffering a concussion and determine the severity of the injury. Although the SCAT3 is utilized frequently a large number of concussions seem to be misdiagnosed. This may be due to the present medical personnel being unfamiliar with the tool or due to poor training.

Injury Location

Overall, with the high number of concussion injuries it is conclusive that the head/face area was the anatomical region that received the highest number of injuries (n=247). This was

followed closely by the shoulder/collar bone area (n=107). By comparison, these findings are similar to the injuries reported by Haseler et al. (2010) who found that the head/neck was the most frequent anatomical site of injury in community level junior rugby. It was also reported by Haseler et al. (2010) that concussion accounted for more than 50% of head/neck injuries. These findings, in combination with the tackle-related data, suggest that there may be a link between poor tackling technique and associated high levels of concussion. McFie et al. (2016) reported that of a total of 108 concussions suffered between 2011 and 2014 at the SA Rugby Youth Week Tournaments, 62% occurred during the tackle event. However, further investigation is required to establish the possible link between poor tackle technique and concussion in this local youth cohort. Regardless of the injury mechanism, this high proportion and incidence of head, neck and shoulder injuries in youth cohorts illustrates the difference between youth and senior rugby. For senior rugby players, lower limb injuries have the highest injury incidence, whereas youth rugby players have a higher injury incidence of head, neck and shoulder injuries. This shift in injury profile illustrates that the injury prevention practices for youth and senior rugby players should be designed accordingly.

The knee area (n=98), followed by the ankle area (n=80), were the lower body anatomical areas that sustained the highest number of *'overall'* injuries. However, these findings contrast the findings of Brooks et al. (2005) that found the Thigh area sustained the greatest proportion of injuries within senior professional cohorts. As reported by Brooks et al. (2005), this was due to players sustaining a higher incidence of injuries in the preseason period. While the authors do not state further reasons, one might presumable that this was due to incorrect training load management.

Study Limitations

As with previous literature (Haseler et al., 2010; Brown et al., 2012) a limitation to this study was the inability to quantify training exposure data during the tournaments. While previous studies assessed training-related injuries only (Lovell et al., 2013) this study assessed competition injuries only. As previously stated, all players who were injured in a match were taken to the TD for medical assessment and treatment. However, due to the short nature of the tournaments players may have attempted to "mask" more severe injuries to prevent being withdrawn from the rest of the tournament. While education of the relevant team management staff on the importance of reporting all complaints, on and off the field, might be a beneficial exercise it is of greater importance to firstly reduce the number of injuries within this cohort. As previously mentioned, another point to consider would be the semi-professional environment of youth rugby. Many of the older teams traveling to the youth tournaments may have employed private medical professionals to assist in player injury management. This would negatively impact the process of reporting injuries to the TD and subsequent data collection procedures. With the growing level of professionalism in sport, steps should be taken to ensure that any non-SARU medical professionals are required to report any injury that is not directly assessed by the TD. It must also be noted that some players may have neglected medical attention from the attending paramedics or medical support staff on the field of play. Subsequently these players may have refrained from reporting to the TD after the match where the injury was sustained. However, this would have been out of the control of the data collection team and TD.

Practical Implications of this study

The research in this thesis has aimed to show if injury rates within youth rugby tournaments changed over time, between 2011 and 2014, or within various age groups. While we have shown this hypothesis to be true (Table 2.1., Table 2.2. (see '*Results*')), further investigation is required to determine the direct cause of this. It must also be noted that the high proportion of injuries sustained in the tackle in the under-13 age group is a cause of concern and further investigation into risk factors associated with participation at under-13 level should be conducted. The effectiveness of the BokSmart Program in reducing severe and catastrophic injuries in junior rugby players is documented (Brown et al., 2016). While this was not a direct aim of this study, it would be interesting to note whether an association exists between the change in injury rates over time and the effectiveness of the BokSmart Program. However, with the lack of injury rate data prior to 2011 and prior to the implementation of the BokSmart Program it may be difficult to establish this relationship from our findings.

The data collected within our study will be useful for SA Rugby when they organise future tournaments. For example they will be able to ensure adequate medical support is provided at these tournaments. The medical support can also be matched to the expected demands of each tournament. However, using IID's alone may not present a clear enough picture for future medical personnel. Examining total injury counts for each tournament will allow more accurate planning for medical infrastructure and personnel requirements. It should also be stated that due to the findings of this study focused attention should be placed on tournaments with a high concussion incidence. Brown et al. (2012) suggested that due to

some tournaments facilitating numerous fixtures concurrently the TD's assessment and treatment of these injuries may not be optimal should he/she be required to assess multiple concussions at one time. Brown et al. (2012) made a further suggestion that allocating one TD per time-loss injury per match would prevent this issue. The findings on concussion, injury location and injury event may provide SA Rugby with a platform to increase player tackle technique education from younger age groups. It may be beneficial to assess the mechanism of future tackle-related injuries through video analysis to determine the underlying cause of injury (poor technique, foul play, mismatch in stature of players, etc.). This may curb the high number of injuries suffered by younger player cohorts. These findings may also allow SA Rugby to improve their facilitation of concussion assessment training given to the allocated TDs before the start of the tournament and ensure the training is thorough. Lastly, as previously mentioned, due to the high overall injury incidence at the Craven Week under-13 tournament in comparison to the other tournaments it may be beneficial to revisit the tournament structure of this tournament. Durandt et al. (2011) found that of the initial 349 players who participated at the Craven Week under-13 tournament, only 32% (n=110) progressed to the Grant Khomo under-16 tournament. They also reported that only 24% (n=84) of the initial 349 players progressed to the Craven Week under-18 tournament (Durandt et al., 2011). It was concluded that players participating at under-13 level do not necessarily become successful at later stages of their careers. Therefore the reasons behind hosting this tournament should be assessed. Barring this, further investigation into possible alteration to the tournament structure, for example introducing a "group" or "playing pool" format, may help reducing injury rates in this age group.

Conclusion

The primary finding of this study was that were significant change in injury rates, both in *'overall'* in *'time-loss'* injuries, over time, and when comparing tournaments. This supports evidence that suggests younger players are at risk of injury. While this is not a new finding when compared to previous literature, specific injury prevention methods should be tailored for the youth cohort. However, while BokSmart, much like RugbySmart, have been instrumental in reducing the number of serious rugby-related youth injuries since its inception (Hendricks, 2010) there has been negative feedback from local coaches and referees attending the BokSmart courses. These programs provide valuable resources and information on injury prevention to local rugby coaches involved with all levels of rugby. However the programs rely on these coaches to disseminate this information to their playing groups and therefore continued commitment from local coaches and referees is vital to the program's success. Brown et al. (2016) found that coaches, and to a lesser extent, physiotherapists, were the preferred source of transferring information to players in team settings. They also found that the injury-prevention information players received was significantly associated with improvement in injury-prevention behaviours, suggesting that coach-driven education was positively associated with injury reduction in the local rugby population (Brown et al., 2016). However, the coaches and referees attending the BokSmart courses concurred that while the program was capable of reducing serious and catastrophic injuries they also agreed than the courses were too long and not practical enough. This fact, combined with the challenges experienced by coaches of varied socioeconomic status on the outcomes of the program (Brown et al., 2016), suggest that more should be done to

reduce the difficulties experienced by local coaches attending the BokSmart program to ensure its long-term success.

Another areas of concern should be the misdiagnosis of concussion-type injuries. This should be an area of concern for SA Rugby and attending medical personnel as a player who suffers a concussion and is allowed to return to play prematurely may be at risk of suffering *'Second Concussion Syndrome'*, or death. Educating coaches and referees on safety in rugby has shown to be effective (Brown, 2016). Therefore further education on the necessary steps involved in concussion management may be warranted. This may take on the form of parent education evenings, social media exposure, concussion guideline re-education for attending tournament medical personnel and prescribed player base-line SCAT3 assessments prior to tournament commencement, etc. However, further steps may be required to prevent further misdiagnosis of concussion. It may be beneficial to examine the possibility of a concussion withdrawal system at local youth week tournaments. This system may red flag concussed players who would be entered onto relevant union team sheets within the tournament and subsequently have the player removed until cleared by the attending TD.

While educating the coaches, players and parents/guardians on the process of return to play following a concussion is vital and currently in place (Viljoen, 2012) the education of these stakeholders should also be aimed at approaching the tackle situation safely. Quarrie and Hopkins (2008) reported that, within senior professional rugby cohorts, tacklers entering the tackle from certain directions had a direct influence on injury profiles (injuries per 1000 player hours). Front-on tackles produced the highest injury incidence (7.7 injuries per 1000 player hours) when compared to tackles from the side (4.3 injuries per 1000 player hours) and tackles from behind (0.9 injuries per 1000 player hours) (Quarrie and Hopkins, 2008).

With this finding in mind, Hendricks and Lambert (2010) concluded that coaching of the tackle should also involve educating players in the how to safely facilitate tackles from the side, tackles from behind and situational tackles to ensure the player uses correct decision making to execute the correct tackle safely. (Hendricks and Lambert, 2010).

In summary, tackle-related and concussion injuries have been shown to have a high incidence at the SA Rugby Youth Week Tournaments. Although the BokSmart Program has focused on tackle education there seems to be a disconnect between coach education and player execution. Arguably this may be due to the short duration and congested structure of the tournaments, however these findings suggest that the tackle events itself may be the main culprit. Therefore, as previously stated, educating both coaches and youth players on safe techniques for executing the tackle from various angles, and not just front-on, may be a necessary consideration.

Appendix

Appendix 1: Youth Week Injury Surveillance Data Capture Form 1

BokSmart
National Rugby Safety Programme

YOUTH WEEKS INJURY SURVEILLANCE DATA CAPTURE FORM

1. PERSONAL DETAILS

Surname:		**Date of birth (dd/mm/yyyy):**	
Full names:		**Date of injury (dd/mm/yyyy):**	
Known as (nickname):		**I.D. Number:**	
Ethnic origin:		**Gender:**	
Height (cm):	**Weight (kg):**	**Age (yrs/months):**	
Club/school/team name:			
Provincial Union:		**Estimated Date of Return from injury (dd/mm/yyyy):**	
Do you have medical insurance?		**Number of days missed due to injury:**	
Did the player consult with a medical professional regarding their injury?			

I understand that the information obtained from the injury report will be treated confidentially with my right to privacy assured. I also understand that should the information be used for a statistical analysis or a scientific report, my identity will not be disclosed in the report.

Player signature		**Date:**	

Appendix 2: Youth Week Injury Surveillance Data Capture Form 2

Team	Age Group	Pitch conditions	Weather conditions*	Mechanism of injury	Type of injury
School	Junior (<U13)	**Option1:**	Hot	Acceleration	***Concussion***
Club	U13	Soft	Dry	Bitten	***Spinal cord injury***
U16 Elite squad	U14	Firm	Light rain	Cleaned	***Broken bone/fracture***
U17 Elite squad	U15	Hard	Heavy rain	Cleaning	***Joint injury***
U18 Elite squad	U16	Very hard	Overcast	Collapsed scrum	***Ligament sprain***
U19 Elite squad	U17	**Option2:**	Cold	Collision	***Muscle strain***
Grant Komo week U16 squad	U18	Even	Windy	Deceleration	***Muscle cramp***
Craven week U13 squad	U19	Uneven	Other	Double tackle (high)	***Tendon injury***
Craven week U18 squad	U20	**Option3:**	**Body location**	Double tackle (regulation)	***Bruise/contusion***
Academy week U18 squad	U21	Muddy	***Head/face (elaborate)***	Elbowed	***Skin abrasion***
SA U18 Academy squad	U23	Slippery		Gouged	***Laceration***
SA Schools U18 squad	Senior	**Option4:**	***Neck/cervical***	Head butt	***Other injury***
Provincial U19 squad	**Position**	Medium grip	***Sternum/ribs***	Jumping	***Unsure/do not know***
Provincial U20 squad	1 - Loose head prop	Solid footing	***Upper back***	Kicked	**Nature of injury**
Provincial U21 squad	2 - Hooker	**Where injury occurred**	***Stomach***	Kneed	***New injury***
SA U19 squad	3 - Tight head prop	Warm-up	***Low back***	Landing	***Old or previous injury***
SA U20 squad	4 - Lock	Cool-down	***Sacrum/pelvis***	Lunge	**Protective gear***
SA U21 squad	5 - Lock	Match	***Shoulder/collarbone***	Not supported	Mouth guard
SA U23 squad	6 - Open side flank	Weight training	***Upper arm***	Other	Shoulder pads
Provincial amateur squad	7 - Blind side flank	Fitness conditioning	***Elbow***	Popped scrum	Headgear
SA Amateur squad	8 - 8th man	Rugby skills (non-contact)	***Forearm***	Punched	Shin-pads
Emerging Boks	9 - Scrum/inside half	Rugby skills (semi-contact)	***Wrist***	Rucked	Strapping
SA (A) squad	10 - Fly/outside half	Rugby skills (full-contact)	***Hand/finger/thumb***	Scrum engagement	Other
Springboks	11 - Left wing	Other	***Hip/groin***	Sidestep	**Injury definition**
Emerging Women's 7's squad	12 - Inside center	**Time in match when injury occurred**	***Front of thigh***	Slipped	***Time loss injury***
Women's provincial U20 squad	13 - Outside center	Warm-up	***Back of thigh***	Tackled from behind (high)	***Medical attention injury***
Women's provincial seniors	14 - Right wing	1st Quarter	***Knee***	Tackled from behind (regulation)	
Women's Bok squad	15 - Full back	2nd Quarter	***Lower leg***	Tackled front-on (high)	**Estimated severity**
Provincial 7's squad	**No. of years at this position**	3rd Quarter	***Ankle***	Tackled front-on (regulation)	***Slight (0-1 day missed)***
Emerging 7's squad	0-1yr	4th Quarter	***Foot/toe***	Tackled side-on (high)	***Minimal (2-3 days missed)***
National 7's squad	1-2yrs	Cool-down	**Injury event**	Tackled side-on (regulation)	***Mild (4-7 days missed)***
League	2-4yrs	**Post-injury decision**	Scrum	Tackling from behind (high)	***Moderate (8-28 days missed)***
Super League A	5-10yrs	Continued	Lineout	Tackling from behind (regulation)	***Severe (>28 days missed)***
Super League B	>10yrs	Discontinued, forced	Open play	Tackling front-on (high)	***Career-ending***
Premier League A	>20yrs	Discontinued, precautionary	Tackle	Tackling front-on (regulation)	***Non-fatal catastrophic***
Premier League B	**Game status within team**	Discontinued, blood	Ball Carry	Tackling side-on (high)	***Fatal***
Division 1	Started match	**Stage of season**	Ruck	Tackling side-on (regulation)	
Division 2	Substitution	Off-season	Maul	**Was the injury a result of foul play?**	**Did the referee take any action?**
Division 3	**Pitch type**	Preseason	Kicking	Yes/No	Yes/No
Division 4	Grass	In-season	Running	Elaborate:	
Division 5	Synthetic	**INSTRUCTIONS FOR USE**: Circle the relevant answer in each section. For "Pitch Conditions", circle one selection under each "Option" provided. Under **"Injury Definition"** the following definitions should be used: A **"Time-loss injury"** is defined as an injury that results in **more** than one (1) day absence from training and/or match play. A **"Medical attention injury"** is defined as an injury that simply requires medical attention.				
N/A	Sand				
	Gravel				
	Other				

Appendix 3: Youth Week Injury Surveillance Follow Up Form

Player Name	
Player Surname	

Team	

(e.g. Zimbabwe)

		Yes	No
1	Did the Player miss >1 match or day of training due to his injury? (Rest day not included)		
2	Did the Player consult with a medical professional for his injury?		
3	Is the Player covered by medical Aid? If so, by what company and scheme? (e.g.Discovery, Hospital Plan)		

Please fill in below:

	Medical Professional	Details (e.g. X-ray, ankle boot, etc.)	OOP/C?	Cost & Currency	Date
	e.g GP	Follow-Up Consultation	C	R 4 000	1/7/2014
	e.g. Specialist	X-Ray	OOP	Zim$ 1600	2/7/2014
1					
2					
3					
4					
5					

* OOP = Out of Pocket Expense, C = Expense covered by Med. Aid

	Parent/Player	Time Lost BEFORE return to sport (e.g. total hours lost to injury)
	e.g. Player	5 days of school (7 x 5 = 35 hours)
1		
2		
3		

Extra Notes:

Appendix 4: Ethics Approval Form 1

UNIVERSITY OF CAPE TOWN

FACULTY OF HEALTH SCIENCES
Human Research Ethics Committee

FHS016: Annual Progress Report / Renewal

HREC office use only (FWA00001637; IRB00001938) This serves as notification of annual approval, including any documentation described below.			
☑ Approved	Annual progress report	Approved until/next renewal date	
☐ Not approved	See attached comments		
Signature Chairperson of the HREC	TBurger	Date Signed	11/12/2014

Comments to PI from the HREC

Principal Investigator to complete the following:

1. Protocol Information

Date (when submitting this form)	6th December, 2016		
HREC REF Number	944/2014	Current Ethics Approval was granted until	30th November, 2016
Protocol title	Incidence and severity of injuries sustained in SARU Youth week tournaments: A 4 year overview		
Protocol number (if applicable)	N/A		
Are there any sub-studies linked to this study?	☐ Yes X No		
If yes, could you please provide the HREC Ref's for all sub-studies? Note: A separate FHS016 must be submitted for each sub-study.	N/A		
Principal Investigator	Prof M. I. Lambert		
Department / Office Internal Mail Address	Division of Exercise Science and Sports Medicine, Department of Human Biology. mike.lambert@uct.ac.za		

1.1 Does this protocol receive US Federal funding?	☐ Yes	X No
~~1.2 If the study receives US Federal Funding, does the annual report require full committee approval?~~	~~☐ Yes~~	~~☐ No~~
1.3 Has sponsorship of this study changed? If yes, please attach a revised summary of the budget.	☐ Yes	X No

HUMAN RESEARCH ETHICS COMMITTEE
- 8 DEC 2016
HEALTH SCIENCES FACULTY
UNIVERSITY OF CAPE TOWN

(Note: Please complete the Closure form (FHS010) if the study is completed before the approval period)

Appendix 5: Ethics Approval Form 2

UNIVERSITY OF CAPE TOWN

FACULTY OF HEALTH SCIENCES
Human Research Ethics Committee

2. List of documentation for approval

The data collection for this study is complete – data are being analysed

3. Protocol status (tick ✓)

☐	Open to enrolment
X	Closed to enrolment (tick ✓)
☐	Research-related activities are ongoing
☐	Research-related activities are complete, long-term follow-up only
X	Research-related activities are complete, data analysis only
☐	Main study is complete but sub-study research-related activities are ongoing
☐	Study is closed → Please submit a Study Closure Form (FHS010)

4. Enrolment

Number of participants enrolled to date	1100
Number of participants enrolled, since last HREC Progress report (continuing review)	1100
Additional number of participants still required	nil

5. Refusals

Total number of refusals (participants invited to join the study, but refused to take part)	nil

6. Cumulative summary of participants

Total number of participants who provided consent	1100
Number of participants determined to be ineligible (i.e. after screening)	nil
Number of participants currently active on the study	1100
Number of participants completed study (without events leading to withdrawal)	1100
Number of participants withdrawn at participants' request (i.e. changed their mind)	nil
Number of participants withdrawn by PI due to toxicity or adverse events	nil
Number of participants withdrawn by PI for other reasons (e.g. pregnancy, poor compliance)	nil
Number of participants lost to follow-up. Please comment below on reasons for loss of follow-up.	nil
Number of participants no longer taking part for reasons not listed above. Please provide reasons below:	nil

(Note: Please complete the Closure form (FHS010) if the study is completed within the approval period)

Appendix 6: Informed Consent Form (Page 1-6)

Schedule I

Under Aged Player Consent Form

No Player may participate in the SARU Youth Week Tournaments if the Under Aged Player Consent Form and Medical Information Form are not completed and signed by the Player and his Parent/Legal Guardian and submitted to the Team Manager.

I, THE UNDERSIGNED:

_____ (Player's name)

_____ (Player's signature)

Duly assisted by my parent/legal guardian (delete what is not applicable):

_____ (Parent/Legal Guardian's name)

_____ (Parent/Legal Guardian's signature);

INTRODUCTION

I acknowledge that my attendance at and participation as a Team Member of my Provincial Union in the SARU Youth Week Tournament will result in certain benefits for me, including the opportunity to attend the Tournament and to participate in this prestigious event.

1. GENERAL ACCEPTANCE AND AGREEMENT

1.1 I accept the invitation to take part in the Tournament in accordance with this Agreement, a copy of which has been provided to the Provincial Union for which I shall be playing and which I have had an opportunity to read, and have read and understood and agree to abide by the terms thereof;

1.2 I agree to observe and abide by in every respect the provisions of the SARU Constitution and Regulations Relating to the Game, these Terms of Participation and any rule, direction or decision of the Tournament Director, SARU, the Disciplinary Committee or of any officer or body appointed or established by SARU pursuant to the Disciplinary Procedures and with the Anti-Doping Programme set out in this Agreement, save where the contrary is expressly stated, any such rules, directions or decisions shall be binding on me and I acknowledge that I shall not have the power to revoke or alter any such decisions;

2. ANTI-DOPING

2.1 I consent and agree to comply with and be bound by all of the provisions of the SARU and IRB Anti-Doping Regulations;

2.2 I acknowledge and agree that the SAIDS has jurisdiction to impose sanctions as provided for in the SARU and IRB Anti-Doping Regulations;

2.3 I agree that if I am on any specific medication which is on the WADA prohibited list, I shall submit a Therapeutic Use Exemption form from SAIDS and will make sure that all the relevant medical documentation (copies will be accepted) relating thereto will be available which will allow me to use the medication;

2.4 I agree that my personal anti-doping data relating to the Doping Control process (including test distribution planning, sample collection and handling, laboratory analysis, result management, hearings and appeals) can be processed (for example transmitted, disclosed, used and stored) by SAIDS.

2.5 I hereby give permission to be tested by the representatives of SAIDS.

3. ANTI-CORRUPTION AND BETTING

I consent and agree to comply with and be bound by all of the provisions of the IRB Anti-Corruption and Betting Regulations (IRB Regulation 6) as in force from time to time (www.irbintegrity.com).

4. DISCIPLINARY MEASURES

I consent and agree to comply with and be bound by IRB Regulation 17 (IRB website), SARU Illegal and Foul Play and Misconduct Regulations for Youth Weeks **(Schedule IV)** and the SARU Disciplinary and Judicial Matters Regulations (SA Rugby website).

Should I be suspended by the Disciplinary Committee from playing for whatever reason, the suspension shall be effective for the determined period during or after the Tournament.

5. EVENT ACTIVATION

I agree to fully participate and co-operate in all the Events as requested by my Team Manager and as directed by SARU.

6. PLAYER ATTRIBUTES

I agree and consent hereby to grant a perpetual license to SARU to utilise my player Attributes (as defined in the Main Agreement) in accordance with Clause 9.2 of this Agreement.

7. MEDICAL CLEARANCE

I am mentally, dentally and physically fit to attend and to participate in the Tournament.

8. MEDICAL AND INJURY DATA FOR RESEARCH

I hereby give consent that my medical and injury information can be used by SARU and their nominated research partners for research purposes.

• By signing this document the player and their parents and/or legal guardian where applicable provides informed consent to access all relevant information and agree to release all injury or illness data obtained during the tournament to SARU, which may or may not be used for research purposes

- All analysed, researched or published information, will remain anonymous, and will be treated and handled with the utmost confidentiality

9. MEDICAL CONSENT

9.1 I hereby give the Team Manager permission to give consent to medical investigations management procedures that may be required to treat injury which I might sustain during the Tournament, and to complete and sign all documents required in this regard. The parent or legal guardian is responsible for all costs pertaining to these medical procedures.

9.2 If injured, I realise that I will be stabilised and assessed at the match venue to the best of the abilities of the contracted Medical Staff at no cost to me, my parent(s)/legal guardian(s) and/or the Provincial Union that I represent.

9.3 If additional referral or specialist medical intervention is required, based on judgement by the contracted Medical Staff, the costs of ambulance transportation, admission to hospital, and the additional assessment or intervention costs, will be for the account of myself or my parent(s)/legal guardian.

9.4 After hour medical services are for my account or that of my parent(s)/legal guardian(s).

9.5 Players with medical aid, who require hospitalisation, will be transported and admitted to the nearest and most appropriate private medical facility or hospital. Any costs over and above those covered by my medical aid, or my parent(s)/legal guardian's medical aid, are for my account or that of my parent(s)/legal guardian(s).

9.6 If I or my parent(s)/legal guardian don't have medical aid, I am aware that I will be transported and admitted to the nearest and most appropriate government or private medical facility or hospital, depending on their individual preference and circumstance.

9.7 I confirm that should I get injured, all costs incurred, are for my account or that of my parent(s)/legal guardian(s).

9.8 I undertake to provide the team manager with all the relevant information and documentation regarding to my medical aid status and any specific medical history.

MEDICAL INFORMATION FORM

Player Details	
First Name:	Surname:
Date Of Birth:	Age:
ID Number:	
School/Club:	Position:
Union:	
Contact Details of Parent and/or legal Guardian	
Home:	Work:
Fax:	Cell:
Email:	
Next of kin	
First Name:	Surname:
Relationship:	
Contact details: Home:	Work/Cell:
Medical Aid Details	
Medical Aid:	Number:
Main Member:	

This form needs to be signed and submitted to my Team Manager who will submit same to the nominated member of the LOC.

Appendix 7: Table 4A. Proportion of injury *'location'* per tournament at South African Rugby Union (SA Rugby) Youth Week Tournaments, 2011-2014.

***'Time-loss'* (TL) injuries are reported separately and as part of the 'Overall' injuries category. The proportion of different injury locations, as reported by the injured player and Tournament Doctor, are shown below. The total number of tournament injuries and calculated number of injuries per match are shown in the sub-section below the main table. The data are presented in *Upper Body* (Table 4A. and 4B.) and *Lower Body* (Table 5A. and 5B.)**

	CW13		GK16		AW18		CW18		OVERALL	
Injury location (%)	**TL**	**ALL**	**TL**	**ALL**	**TL**	**ALL**	**TL**	**ALL**	**TL**	**ALL**
Head/Face	30	23	36	37	34	25	32	31	**33**	**28**
Neck/Cervical	4	8	5	4	5	7	10	6	**6**	**7**
Shoulder/Collar Bone	11	9	15	9	16	13	25	18	**17**	**12**
Sternum/Ribs	0	3	0	4	1	2	1	3	**1**	**3**
Stomach	0	0	0	0	0	1	0	1	**0**	**1**
Upper Back	1	3	0	1	1	1	0	0	**0**	**2**
Upper Arm	4	2	0	1	0	0	0	0	**1**	**1**
Elbow	3	1	2	3	0	1	0	1	**1**	**2**
Forearm	3	4	0	0	1	1	0	0	**1**	**2**
Wrist	7	4	2	1	2	3	2	2	**3**	**2**
Hand/Finger/Thumb	1	6	2	6	4	8	1	3	**2**	**6**
Total injuries	**73**	**220**	**66**	**168**	**85**	**260**	**79**	**227**	**303**	**875**
Injuries per match (n)	**0.5**	**1.5**	**0.6**	**1.4**	**0.5**	**1.7**	**0.7**	**0.9**	**0.6**	**1.6**

CW13 – Craven Week under-13, GK16 – Grant Khomo under-16, AW18 – Academy Week under-18, CW18 – Craven Week under-18

** When combined with Table 5A, the column totals add up to 100*

Appendix 8: Table 4B. Proportion of injury *'location'* per year at South African Rugby Union (SA Rugby) Youth Week Tournaments, 2011-2014.

***'Time-loss'* (TL) injuries are reported separately and as part of the 'Overall' injuries category. The proportion of different injury locations, as reported by the injured player and Tournament Doctor, are shown below. The total number of tournament injuries and calculated number of injuries per match are shown in the sub-section below the main table. The data are presented in *Upper Body* (Table 4A. and 4B.) and *Lower Body* (Table 5A. and 5B.)**

	2011		2012		2013		2014		OVERALL	
Injury location (%)	**TL**	**ALL**	**TL**	**ALL**	**TL**	**ALL**	**TL**	**ALL**	**TL**	**ALL**
Head/Face	37	31	29	26	23	30	39	27	**33**	**28**
Neck/Cervical	5	8	6	7	8	6	5	5	**6**	**7**
Shoulder/Collar Bone	23	16	19	11	17	11	9	12	**17**	**12**
Sternum/Ribs	2	3	0	1	0	2	0	4	**1**	**3**
Stomach	0	0	0	1	0	1	0	0	**0**	**1**
Upper Back	0	1	0	2	0	1	1	1	**0**	**2**
Upper Arm	0	1	3	1	0	0	1	2	**1**	**1**
Elbow	0	1	1	1	4	2	1	2	**1**	**2**
Forearm	0	0	0	1	2	1	2	3	**1**	**2**
Wrist	2	2	3	2	0	1	8	3	**3**	**2**
Hand/Finger/Thumb	3	5	1	8	0	2	2	6	**2**	**6**
Total injuries	**92**	**189**	**79**	**247**	**52**	**176**	**80**	**263**	**303**	**875**
Injuries per match (n)	**0.7**	**1.4**	**0.6**	**1.8**	**0.4**	**1.3**	**0.6**	**1.9**	**0.6**	**1.8**

** When combined with Table 5B, the column totals add up to 100*

Appendix 9: Table 5A. Proportion of injury *'location'* per tournament at South African Rugby Union (SA Rugby) Youth Week Tournaments, 2011-2014.

***'Time-loss'* (TL) injuries are reported separately and as part of the 'Overall' injuries category. The proportion of different injury locations, as reported by the injured player and Tournament Doctor, are shown below. The total number of tournament injuries and calculated number of injuries per match are shown in the sub-section below the main table. The data are presented in *Upper Body* (Table 4A. and 4B.) and *Lower Body* (Table 5A. and 5B.)**

	CW13		GK16		AW18		CW18		OVERALL	
Injury location (%)	**TL**	**ALL**	**TL**	**ALL**	**TL**	**ALL**	**TL**	**ALL**	**TL**	**ALL**
Lower Back	3	2	3	3	0	2	0	3	**1**	**2**
Sacrum/Pelvis	0	1	0	0	0	0	0	0	**0**	**0**
Hip/Groin	1	1	2	2	0	2	0	2	**1**	**2**
Front of Thigh	0	3	2	2	2	3	3	1	**2**	**2**
Back of Thigh	3	3	0	1	1	2	3	4	**2**	**3**
Knee	19	14	14	12	6	9	11	10	**12**	**11**
Lower Leg	3	5	3	5	5	5	1	3	**3**	**4**
Ankle	3	3	14	8	22	13	11	11	**13**	**9**
Foot/Toe	4	5	0	1	0	0	0	0	**1**	**1**
Not reported	*0*	*0*	*0*	*0*	*0*	*2*	*0*	*1*	***0****	***1****
Total injuries	**73**	**220**	**66**	**168**	**85**	**260**	**79**	**227**	**303**	**875**
Injuries per match (n)	**0.5**	**1.5**	**0.6**	**1.4**	**0.5**	**1.7**	**0.7**	**0.9**	**0.6**	**1.6**

CW13 – Craven Week under-13, GK16 – Grant Khomo under-16, AW18 – Academy Week under-18, CW18 – Craven Week under-18

**Mechanism of injury captured but no original location data recorded*

**When combined with Table 4A, the column totals add up to 100*

Appendix 10: Table 5B. Proportion of injury *'location'* per year at South African Rugby Union (SA Rugby) Youth Week Tournaments, 2011-2014.

***'Time-loss'* (TL) injuries are reported separately and as part of the 'Overall' injuries category. The proportion of different injury locations, as reported by the injured player and Tournament Doctor, are shown below. The total number of tournament injuries and calculated number of injuries per match are shown in the sub-section below the main table. The data are presented in *Upper Body* (Table 4A. and 4B.) and *Lower Body* (Table 5A. and 5B.)**

	2011		2012		2013		2014		OVERALL	
Injury location (%)	**TL**	**ALL**	**TL**	**ALL**	**TL**	**ALL**	**TL**	**ALL**	**TL**	**ALL**
Lower Back	1	3	1	2	0	2	3	2	**1**	**2**
Sacrum/Pelvis	0	0	0	0	0	1	0	0	**0**	**0**
Hip/Groin	1	2	1	2	2	2	0	2	**1**	**2**
Front of Thigh	2	3	3	3	2	2	0	2	**2**	**2**
Back of Thigh	2	3	3	3	0	2	1	3	**2**	**3**
Knee	9	11	11	9	19	14	13	12	**12**	**11**
Lower Leg	2	2	5	5	2	6	3	5	**3**	**4**
Ankle	11	7	13	10	19	11	11	8	**13**	**9**
Foot/Toe	0	1	1	2	2	3	1	1	**1**	**1**
Not reported	*0*	*0*	*0*	*3*	*0*	*0*	*0*	*0*	***0***	***1****
Total injuries	**92**	**189**	**79**	**247**	**52**	**176**	**80**	**263**	**303**	**875**
Injuries per match (n)	**0.7**	**1.4**	**0.6**	**1.8**	**0.4**	**1.3**	**0.6**	**1.9**	**0.6**	**1.8**

** When combined with Table 4B, the column totals add up to 100*

References

1. Archbold, H. A. P., Rankin, A. T., Webb, M., Nicholas, R., Eames, N. W. A., Wilson, R. K. RISUS study: Rugby Injury Surveillance in Ulster Schools. *British Journal of Sports Medicine* 600-606, 51(7), 2017.
2. Badenhorst, M, Verhagen, E.A.L.M, Van Mechelen, W, Lambert, M.I., Viljoen, W, Readhead, C, Baerecke, G, Brown, J.C. A comparison of catastrophic injury incidence rates by Provincial Rugby Union in South Africa. *Journal of Science and Medicine in Sport* DOI: 10.1136/bjsports-2016-096757.
3. Bathgate A, Best J.P., Craig G. A prospective study of injuries to elite Australian rugby union players. *British Journal of Sports Medicine* 265-269, 36, 2002.
4. BokSmart, What is BokSmart, 2017a. [http://boksmart.sarugby.co.za/content/what-is-boksmart]. Accessed 5 January 2017.
5. BokSmart, Safe-Six, 2017b. [http://boksmart.sarugby.co.za/content/safe-six]. Accessed 5 January 2017.
6. BokSmart, Coaches and Referees, 2017c. [http://boksmart.SA Rugbygby.co.za/content/coaches-and-referees]. Accessed 5 January 2017.
7. Brooks, J.H.M., Fuller, C.W., Kemp, S.P.T., Reddin, D.B. Epidemiology of injuries in English professional rugby union: part 1 match injuries. *British Journal of Sports Medicine* 757-766, 39, 2005a.

8. Brooks, J.H.M., Fuller, C.W., Kemp, S.P.T., Reddin, D.B. Epidemiology of injuries in English professional rugby union: part 2 training injuries. *British Journal of Sports Medicine* 767-775, 39, 2005b.
9. Brown, J.C., Gardener-Lubbe, S, Lambert, M.I., Van Mechelen, W, Verhagen, E. Coach-directed education is associated with injury prevention behaviour in players: an ecological cross-sectional study. *British Journal of Sports Medicine* DOI: 10.1136/bjsports-2016-096757
10. Brown, J.C., Verhagen, D, Knol, D, Van Mechelen, W, Lambert, M.I. The effectiveness of the nationwide BokSmart rugby injury prevention program on catastrophic injury rates. *Scandinavian Journal of Medicine & Science in Sports* 221-225, 26, 2016.
11. Brown, J.C., Verhagen, E, Viljoen, W, Readhead, C, Van Mechelen, W, Hendricks, S, Lambert, M.I. The incidence and severity of injuries at the 2011 South African Rugby Union (SARU) Youth Week tournaments. *South African Journal of Sports Medicine* 49-54, 24, 2012.
12. Brown, J.C., Lambert, M.I., Lubbe, S., van Mechelen, W, Verhagen, E. Improvements in Injury Prevention Behaviours of rugby union players associated with BokSmart intervention programme. *British Journal of Sports Medicine* 574, 48, 2014.
13. Brown, J.C. The introduction of an international model to reduce injuries in Rugby Union in South Africa. *South African Journal of Sports Medicine* 62-63, 23(2), 2011b
14. Burger, N., Lambert, M.I., Viljoen, W, Brown, J.C., Readhead, C, Hendricks, S. Tackle-related injury rates and nature of incidence of injuries in South African

Youth Week tournament rugby union players (under-13 to under-18): an observational cohort study. *British Medical Journal* 1-7, 4, 2014.

15. Burger, N., Lambert, M. I., Viljoen, W., Brown, J. C., Readhead, C., & Hendricks, S. Tackle technique and tackle-related injuries in high-level South African Rugby Union under-18 players: real-match video analysis. *British Journal of Sports Medicine* 932-938, 50(15), 932–938, 2016.
16. Burger, N., Lambert, M. I., Viljoen, W., Brown, J. C., Readhead, C., Hollander, den, S., & Hendricks, S. Mechanisms and Factors Associated With Tackle-Related Injuries in South African Youth Rugby Union Players. *The American Journal of Sports Medicine* 278–285, 45(2), 2017.
17. Chalmers, D.J., Samaranayaka, A, Gulliver, P, McNoe, B. Risk factors for injury in rugby union football in New Zealand: a cohort study. *British Journal of Sports Medicine* 95-102, 46, 2012.
18. Collins, C.L., Micheli, L.J., Yard, E.E., Comstock, R.D. Injuries sustained by High School Rugby Players in the United States, 2005-2006. *Archive of Pediatrics and Adolescent Medicine* 49-54, 162 (1), 2008.
19. Corson, J. For Poulton and England: The life and times of an Edwardian rugby hero. 1st ed. England: Leicester, 53, 2009.
20. Cross, M. J., Williams, S., Trewartha, G., Kemp, S. P., & Stokes, K. A. The Influence of In-Season Training Loads on Injury Risk in Professional Rugby Union. *International Journal of Sports Physiology and Performance* 350-355, 11(3), 2016.

21. Cunningham, D., Shearer, D.A., Drawer, S., Pollard, B., Eager, R., Taylor, N., Cook, C., Kilduff, L.P. Movement Demands of Elite Under-20s and Senior International Rugby Union Players. *Public Library of Science* 1-13, 11 (11), 2016.

22. Du Toit, J. Playing time of senior rugby players across all levels of South African rugby, 2007 –2012: implications for transformation. MSc thesis, University of Cape Town, 1-77, 2014.

23. Durandt, J, Parker, Z, Masimla, H, Lambert, M.I. Rugby-playing history at the national U13 level and subsequent participation at the national U16 and U18 rugby tournaments. *South African Journal of Sports Medicine* 103-105, 23(4), 2011.

24. Duthie, G, Pyne, D, Marsh, D, and Hooper, S. Sprint patterns in rugby union players during competition. *Journal of Strength and Conditioning Research* 208-214, 20(1), 2006.

25. Freitag, A., Kirkwood, G., Pollock, A. Rugby injury surveillance programmes: are they effective? *British Medical Journal* 1587, 350, 2015.

26. Freitag, A., Kirkwood, G., Scharer, S., Ofori-Asenso, R., & Pollock, A. M. Systematic review of rugby injuries in children and adolescents under 21 years. *British Journal of Sports Medicine* 511-519, 49, 2015.

27. Fuller, C.W., Molloy, M.G., Bagate, C. Consensus statement on injury definitions and data collection procedures for studies of injuries in rugby union. *British Journal of Sports Medicine* 328-331, 41, 2007.

28. Fuller, C.W., Brooks, J.H.M., Cancea, R.J., Hall, J, Kemp, S.P.T. Contact events in rugby union and their propensity to cause injury. *British Journal of Sports Medicine* 862-867, 41, 2007.

29. Fuller, C.W., Molloy M.G. Epidemiological study of injuries in men's international under-20 rugby union tournaments. *Clinical Journal of Sport Medicine* 356-358, 21(4), 2011.

30. Fuller, C. W., Taylor, A., & Raftery, M. Eight-season epidemiological study of injuries in men's international Under-20 rugby tournaments. *Journal of Sports Sciences* 00(00), 1–8, 2017.

31. Gabbett, T.J. Incidence of injury in junior rugby league players over four competitive seasons. *Journal of Science and Medicine in Sport* 323-328, 11, 2008.

32. Gabbett, T.J. Severity and cost of injuries in amateur rugby league: A case study. *Journal of Sports Sciences* 341-347, 19, 2001.

33. Gabbett, T.J. Incidence of injury in junior and senior rugby league players. *Sports Medicine* 849-859, 34(12), 2004.

34. Gabbett T.J., Domrow N. Risk factors for injury in sub-elite rugby league players. *American Journal of Sports Medicine* 428-434, 33, 2005.

35. Gabbett, T.J. Influence of fatigue on tackling technique in rugby league players. *Journal of Strength and Conditioning Research* 625-632, 22, 2008.

36. Garraway, W.M., Lee A.J., Hutton S.J. Impact of professionalism on injuries in rugby union. *British Journal of Sports Medicine* 348-351, 34, 2000.

37. Gianotti, S.M., Quarrie, K.L., Hume, P.A., Evaluation of RugbySmart: A rugby union community injury intervention programme. *Journal of Science and Medicine in Sport* 371-375, 12(3), 2009.

38. Guttman, A. Sports: The first five Millenia. Massachutus: Amherst, 115, 2004.

39. Haseler, C.M., Carmont, M.R., England, M. The epidemiology of injuries in English youth community rugby union. *British Journal of Sports Medicine* 1093-1099, 44, 2010.

40. Hendricks, S, Lambert, M.I. Tackling in Rugby: Coaching Strategies for Effective Technique and Injury Prevention. *International Journal of Sports Science and Coaching* 117-135, 5, 2010.

41. Hislop, M. D., Stokes, K. A., Williams, S., McKay, C. D., England, M. E., Kemp, S. P. T., & Trewartha, G. Reducing musculoskeletal injury and concussion risk in schoolboy rugby players with a pre-activity movement control exercise programme: a cluster randomised controlled trial. *British Journal of Sports Medicine* 1140-1146, 51(15), 2017.

42. Lambert, M.I., Durandt, J. Long-term player development in rugby – how are we doing in South Africa? *South African Journal of Sports Medicine* 67-68, 22 (3), 2010.

43. Lee, A.J., Garraway, W.M. Epidemiological comparison of injuries in school and senior club rugby. *British Journal of Sports Medicine* 213-217, 30, 1996.

44. Leung, F. T., Smith, M. M. F., Hides, J. A., Leung, F. T., Smith, M. M. F., & Hides, J. A. Injuries in Australian school-level rugby union. *Journal of Sports Sciences* 2088-2092, 1–5, 2016.

45. Lovell, T, Sirotic, A, Impellizzeri, F, Coutts, A. Factors affecting perception of effort (session rating of perceived exertion) during rugby league training. *International Journal of Sports Physiology and Performance* 62-69, 8(1), 2013.

46. McFie, S, Brown, J.C., Hendricks, S, Posthumus, M, Readhead, C, Lambert, M, September, A.V., Viljoen, W. Incidence and Factors Associated with Concussion

Injuries at the 2011 to 2014 South African Rugby Union Youth Week Tournament, *Clinical Journal of Sports Medicine* 398-404, 26(5), 2016.

47. McIntosh, A.S., McCrory, P, Finch, C.F., Wolfe, R. Head, face and neck injuries in youth rugby. *British Journal of Sports Medicine* 188-193, 44, 2010.
48. Moore, I. S., Ranson, C., & Mathema, P. Injury Risk in International Rugby Union: Three-Year Injury Surveillance of the Welsh National Team. *Orthopaedic Journal of Sports Medicine*, 3(7), 2015.
49. New Zealand Rugby, Safe Play, 2017. [http://www.nzrugby.co.nz/safe-play]. Accessed 5 January 2017.
50. Nicol, A, Pollock, A, Kirkwood, G, Parekh, N, Robson, J. Rugby Union Injuries in Scottish Schools. *Journal of Public Health* 256-261, 33(2), 2010.
51. Nutton, R.W., Hamilton, D.F., Hutchison, J.D., Mitchell, M.J., Simpson, A.H.R.W., MacLean, J.G.B. Variations in physical development in schoolboy rugby players: can maturity testing reduce mismatch? *British Medical Journal* 1-6, 2(4), 2012.
52. Palmer-Green, D. S., Stokes, K. A., Fuller, C. W., England, M., Kemp, S. P. T., & Trewartha, G. Training activities and injuries in English youth academy and schools rugby union. *The American Journal of Sports Medicine* 475–481, 43(2), 2015.
53. Quarrie, K.L., Gianotti, S.M., Hopkins, W.G., Hume, P.A. Effect of nationwide injury prevention programme on serious spinal injuries in New Zealand rugby union: ecological study. *British Journal of Medicine* 1150-1153, 334, 2007.
54. Read, D., Weaving, D., Phibbs, P., Darrall-Jones, J., Roe, G., Weakley, J., Hendricks, S., Till, K., Jones, B. Movement and physical demands of school and university

rugby union match-play in England. *British Medical Journal Open Sport & Exercise Medicine* 2-1, 2017.

55. Sobue, S., Kawasaki, T., Hasegawa, Y., Shiota, Y., Ota, C., Yoneda, T., et al. (2017). Tackler's head position relative to the ball carrier is highly correlated with head and neck injuries in rugby. *British Journal of Sports Medicine* 353-358, 52, 2018.
56. Targett, S.G. Injuries in professional rugby union. *Clinical Journal of Sports Medicine* 280-285, 8, 1998.
57. van Mechelen W, Hlobil H, Kemper H.C. Incidence, severity, aetiology and prevention of sports injuries. A review of concepts. *Sports Medicine* 82-99, 14, 1992.
58. Venter, R.E., Opperman, E, Opperman, S. The use of Global Positioning System (GPS) tracking devices to assess movement demands and impacts in Under-19 Rugby Union match play. *African Journal of Physical, Health Education, Recreation and Dance* 1-8, 17(1), 2011.
59. Viljoen W, Patricious J. BokSmart – Implementing a National Rugby Safetly Programme. *British Journal of Sports Medicine* 692-693, 46(10), 2012.
60. Williams, S, Trewartha, G, Kemp, S, Stokes, K. A Meta-Analysis of Injuries in Senior Men's Professional Rugby Union. *Journal of Sports Medicine* 1043-1055, 43(10), 2013.
61. Williams, S, Trewartha, G, Kemp, S.P.T., Brooks, J.H.M., Fuller, C.W., Taylor, A.E., Cross, M.J., Stokes, K.A. Time loss injuries compromise team success in Elite Rugby Union: a 7-year prospective study. *British Journal of Sports Medicine* 651-656, 50, 2016.

62. Williams, S., Trewartha, G., Kemp, S. P. T., Brooks, J. H. M., Fuller, C. W., Taylor, A. E. How Much Rugby is Too Much? A Seven-Season Prospective Cohort Study of Match Exposure and Injury Risk in Professional Rugby Union Players. *Sports Medicine* 2395-2402, 47(11), 2017.

63. World Health Organization, Fact Files, Physical Activity. [http://www.who.int/features/factfiles/physical_activity/en/] Accessed 16 February, 2017.

64. World Rugby, Concussion Management for the General Public, 2017d. [http://www.playerwelfare.worldrugby.org/concussion] Accessed 16 February, 2017. pp. 1-7.).

65. World Rugby, History of Sevens Rugby, 2017a. [http://www.worldrugby.org/sevens/history-of-sevens.] Accessed 20 January, 2017.

66. World Rugby, Laws, 2017c. [http://laws.worldrugby.org/?law=1] Accessed 5 January, 2017.

67. World Rugby, Player Numbers, 2017b. http://www.worldrugby.org/development/player-numbers.] Accessed 10 November, 2016 and 10 March, 2017.

68. Yengo-Kahn, A. M., Hale, A. T., Zalneraitis, B. H., Zuckerman, S. L., Sills, A. K., Solomon, G. S. The Sport Concussion Assessment Tool: a systematic review. *Neurosurgical Focus* E6, 40(4), 2016.

69. Yeomans, C., Kenny, I. C., Cahalan, R., Warrington, G. D., Harrison, A. J., Hayes, K., et al. (2017). The Incidence of Injury in Amateur Male Rugby Union: A Systematic Review and Meta-Analysis. *Sports Medicine*, 1–12, 2017.